

TELECOMMUNICATIONS ANNUAL PLANNING REPORT

INPUT

About INPUT

INPUT provides planning information, analysis, and recommendations to managers and executives in the information processing industries. Through market research, technology forecasting, and competitive analysis, INPUT supports client management in making informed decisions. Continuing services are provided to users and vendors of computers, communications, and office products and services.

The company carries out continuous and in-depth research. Working closely with clients on important issues, INPUT's staff members analyze and interpret the research data, then develop recommendations and innovative ideas to meet clients' needs.

Clients receive reports, presentations, access to data on which analyses are based, and continuous consulting.

Many of INPUT's professional staff members have nearly 20 years' experience in their areas of specialization. Most have held senior management positions in operations, marketing, or planning. This expertise enables INPUT to supply practical solutions to complex business problems.

Formed in 1974, INPUT has become a leading international planning services firm. Clients include over 100 of the world's largest and most technically advanced companies.

Offices

NORTH AMERICA

Headquarters
1943 Landings Drive
Mountain View, CA
94043
(415) 960-3990
Telex 171407

Detroit
220 East Huron
Suite 209
Ann Arbor, MI 48104
(313) 971-0667

New York
Park 80 Plaza West-1
Saddle Brook, NJ 07662
(201) 368-9471
Telex 134630

Washington, D.C.
11820 Parklawn Drive
Suite 201
Rockville, MD 20852
(301) 231-7350

EUROPE

United Kingdom
INPUT, Ltd.
Airwork House
35 Piccadilly
London, W1V 9PB
England
01-439-8985
Telex 23116

France
La Nacelle
Procedure d'abonnement 1-74
2, rue Campagne Premiere
75014 Paris
France
322.56.46
Telex 220064 X5533

Italy
PGP Sistema SRL
20127 Milano
Via Soperga 36
Italy
Milan 284-2850
Telex 310352

Sweden
Athena Konsult
P.O. Persson & Co. AB
Box 22114
S-104 22 Stockholm
Sweden
08-52 07 20
Telex 17041

West Germany
NOVOTRON GmbH
Am Elizabethenbrunnen 1
D-6380 Bad Homburg
West Germany
(06172) 44402
Telex 418094

ASIA/AUSTRALIA

Japan
Overseas Data Service
Company, Ltd.
Shugetsu Building
No. 12-7 Kita Aoyama
3-Chome Minato-ku
Tokyo, 107
Japan
(03) 400-7090
Telex 26487

K.K. Ashisuto
Daini-Suzumaru Bldg., 6th Floor
8-1, Nishi Shimbashi
3-Chome Minato-ku
Tokyo, 105, Japan
(03) 437-0654
Telex 781 26196

Singapore
Cyberware Consultants (PTE) Ltd.
2902 Pangkor
Ardmore Park
Singapore 1025
734-8142

INPUT
Planning Services For Management

TELECOMMUNICATIONS ANNUAL PLANNING REPORT

-CCSJ75

U-TAR
1984 c. 1

AUTHOR

Telecommunications Annual Planning

TITLE

Report

BRO
ART

CAT No. 23-108 PRINTED IN U.S.A.

TELECOMMUNICATIONS ANNUAL PLANNING REPORT

ABSTRACT

INPUT's Telecommunications Annual Planning Report is designed to help senior managers and corporate executives assess the effects of change and the opportunities they present to better anticipate telecommunications technology trends and their economic impact on the user community as a whole. It contains an executive summary; a survey of telecommunications technology; a delineation of the network control process and the impact of network control centers; an evaluation of the economic impact of the technology, particularly of the impact of AT&T's divestiture; and finally, a concluding chapter devoted to conclusions and recommendations, with definitions of issues that directly affect the business planning process.

This report contains 117 pages, including 32 exhibits.

**TELECOMMUNICATIONS
ANNUAL PLANNING REPORT**

CONTENTS

		<u>Page</u>
I	INTRODUCTION	1
A.	Purpose and Scope	1
B.	Report Organization	2
C.	Methodology	3
D.	Other Related INPUT Reports	3
II	EXECUTIVE SUMMARY	7
A.	The PBX Market Is in a State of Major Transition	8
B.	Systems, Lines, and Revenues Are All Growing Rapidly	10
C.	There Are New Opportunities for PBX Growth	12
D.	The PBX Market Is Dominated by Two Giants	14
E.	The Shakeout Will Continue	16
F.	The Phone Companies Are Becoming PBX Channels of Distribution	18
III	TECHNOLOGY REVIEW/ANALYSIS	21
A.	Introduction	21
B.	Evolution of the Modern PBX	22
1.	PBXs versus LANs	22
2.	Integrated Office Systems	25
3.	Analog versus Digital	26
4.	PBX Generations	27
5.	Higher Data Transfer Rates	32
6.	PBX Vendors Offering LANs	33
7.	New Microprocessor Technology	34
8.	Super PABXs/CBXs--Voice/Data Integration	35
C.	Satellite Communications	37
1.	Introduction	37
2.	Transponders	44
D.	Fiber Optics	47
1.	Introduction	47
2.	Technology	48
3.	Types of Competitors	50
E.	Leases	54
1.	Introduction	54
2.	Technology	54

	<u>Page</u>
F. Microwave	56
1. Introduction	56
2. Technology	57
3. Digital Microwave	59
4. Impact of Digital Termination Services	64
G. Infrared	65
H. Conclusions	66
 IV ECONOMIC IMPACT/ANALYSIS	67
A. "Embedded" PBX Equipment	67
B. AT&T's Migration Strategy	72
C. Centrex versus On-Premises PBXs	75
D. "Bypass"	76
E. Expected Supplier Shakeout	76
F. Merging of PBX and Computer Companies	78
G. Voice/Data Workstations	79
H. Prices and Costs	80
I. The Multitenant PBX Business	81
J. Problems in Implementation	84
K. Conclusions	87
L. Exhibits	87
 V CONCLUSIONS AND RECOMMENDATIONS	109
A. Conclusions	109
B. Recommendations	111
 APPENDIX A: SURVEY QUESTIONNAIRE	115
 APPENDIX B: LIST OF ABBREVIATIONS.....	117

**TELECOMMUNICATIONS
ANNUAL PLANNING REPORT**

EXHIBITS

		<u>Page</u>
II	-1 The PBX Market Is in a State of Major Transition -2 Systems, Lines, and Revenues Are All Growing Rapidly -3 There Are New Opportunities for PBX Growth -4 The PBX Market Is Dominated by Two Giants -5 The Shakeout Will Continue -6 The Phone Companies Are Becoming PBX Channels of Distribution	9 11 13 15 17 19
III	-1 Digital Communications Use by Major Application, 1980-1990 -2 Cost per Channel per Month versus Channel Length -3 Typical Satellite Costs Using TDMA -4 Typical Satellite Costs Using FM -5 Fiber Cable versus Twisted-Pair Copper Prices, 1980-1990 -6 Typical Fiber Optic Costs -7 Optical Fiber Cost versus Capacity (Mbps) -8 Optical Fiber Costs -9 The Microwave Market -10 U.S. Microwave Equipment Market by Major Application -11 U.S. Microwave Equipment Market by Supplier -12 Worldwide Microwave Equipment Revenues, 1980-1990 -13 Major Microwave Equipment Manufacturers	28 40 41 42 49 51 52 53 58 60 61 62 63
IV	-1 Use of Telecommunications Services by Size of Company -2 U.S. PBX Revenues, 1983-1988 -3 U.S. PBX Market Share Trends by Size of Switch, 1983-1988 -4 Comparison of PBX Revenues (Basic Applications) versus Other PBX-Related Revenues -5 1983 U.S. PBX Market Shares by Manufacturer--For Systems Under 100 Lines -6 1983 U.S. PBX Market Shares by Manufacturer--Systems 100-499 Lines -7 1983 U.S. PBX Market Shares by Manufacturer--Systems Over 499 Lines -8 PBX Market Shares by Major Channels of Distribution--ATT-I.S./RBOCs	86 88 89 94 96 97 98 100

Page

-9	U.S. PBX Market Shares by Major Channels of Distribution--Independent Telcos	101
-10	U.S. PBX Market Shares by Major Channels of Distribution--Interconnects	102
-11	1983 U.S. PBX Market Shares by Manufacturer--Total Market	104
-12	1983 PBX Shipments by Switch Size--Systems	106
-13	1983 PBX Shipments by Switch Size--Lines	107

000075

I INTRODUCTION



Digitized by the Internet Archive
in 2014

<https://archive.org/details/20227MSDBxx84Telecommunic>

I INTRODUCTION

- This report is part of INPUT's Telecommunications Planning Program. Designed to help appraise senior managers and corporate executives of changes in telecommunications technology, and to identify some of the factors influencing that technology, the report:
 - Identifies technological telecommunications requirements.
 - Defines and analyzes current and projected technology and communications innovations.
 - Analyzes cost factors affecting telecommunications utilization and implementation.
 - Identifies trust and direction of telecommunications growth and development.

A. PURPOSE AND SCOPE

- The changing complexion of telecommunications and its attendant growth patterns and trends are of immense interest to business executives, managers, and users alike. The identified necessity for telecommunications fluency on which to base business decisions mandates that managers and users acquire

insights into the technology and its economic factors. Only in this way can users fully utilize the available capability in order to properly exploit the features and techniques most applicable to the needs of their businesses.

B. REPORT ORGANIZATION

- This report is organized along the following lines:
 - Chapter I is an introduction and sets the stage for what follows.
 - Chapter II is an executive summary, formatted as a presentation for group discussions, and emphasizing the key points within the report.
 - Chapter III is a technological assessment of the field and includes a survey of the technology to date.
 - Chapter IV is an assessment of cost factors and economic considerations and outlines some basic principles.
 - Chapter VI contains INPUT's conclusions and recommendations for effective telecommunications strategic planning.
 - The Appendix contains the survey forms used to conduct the interviews identifying what others are doing with respect to telecommunications requirements and utilization.

C. METHODOLOGY

- The information contained in this report was derived from the following sources:
 - Over 30 interviews with senior marketing, telecommunications planning, and information systems managers and executives. Copies of the relevant questionnaire are contained in the Appendix.
 - Over 12 in-depth interviews with senior planning managers and executives. Copies of these questionnaires are also contained in the Appendix.
 - INPUT's own studies on telecommunications.
 - Open literature surveys.
- INPUT has taken the best practices and proposals and subjected them to further analysis to serve as a basis for this report.

D. OTHER RELATED INPUT REPORTS

- Interested readers are referred to the following INPUT reports:
 - Telecommunications Planning Methodologies, November 1984.
 - . Defines and describes telecommunications planning techniques and processes, using the case example approach, and further identifies critical telecommunications planning issues.

- Annual Information Systems Planning Report, July 1984.
 - Evaluates information systems trends and graphically plots critical IS management issues.
- Impact of Communications Developments on Information Services Vendors, December 1981.
 - Analyzes changing communications technology and services as related to information services activities.
- Effective Corporate Planning in the Computer Services Industry, December 1980.
 - Examines the level and extent of corporate, market, industry, and product planning within the computer services industry. Emphasis is on corporate planning efforts.
- User Communication Networks and Needs, November 1980.
 - Identifies and evaluates changes in user needs within the communications field, with particular emphasis on network problems and solutions.
- Digest of Trends in the United States Telecommunications Industry, 1980.
 - A special study for a foreign governmental agency, the report discusses the trust and direction of telecommunications effort in the U.S.

- Planning--A Methodology for Protecting Your EDP Investment, 1979.
 - . A basic planning methodology document, with emphasis on techniques and approaches, rather than technology.

II EXECUTIVE SUMMARY

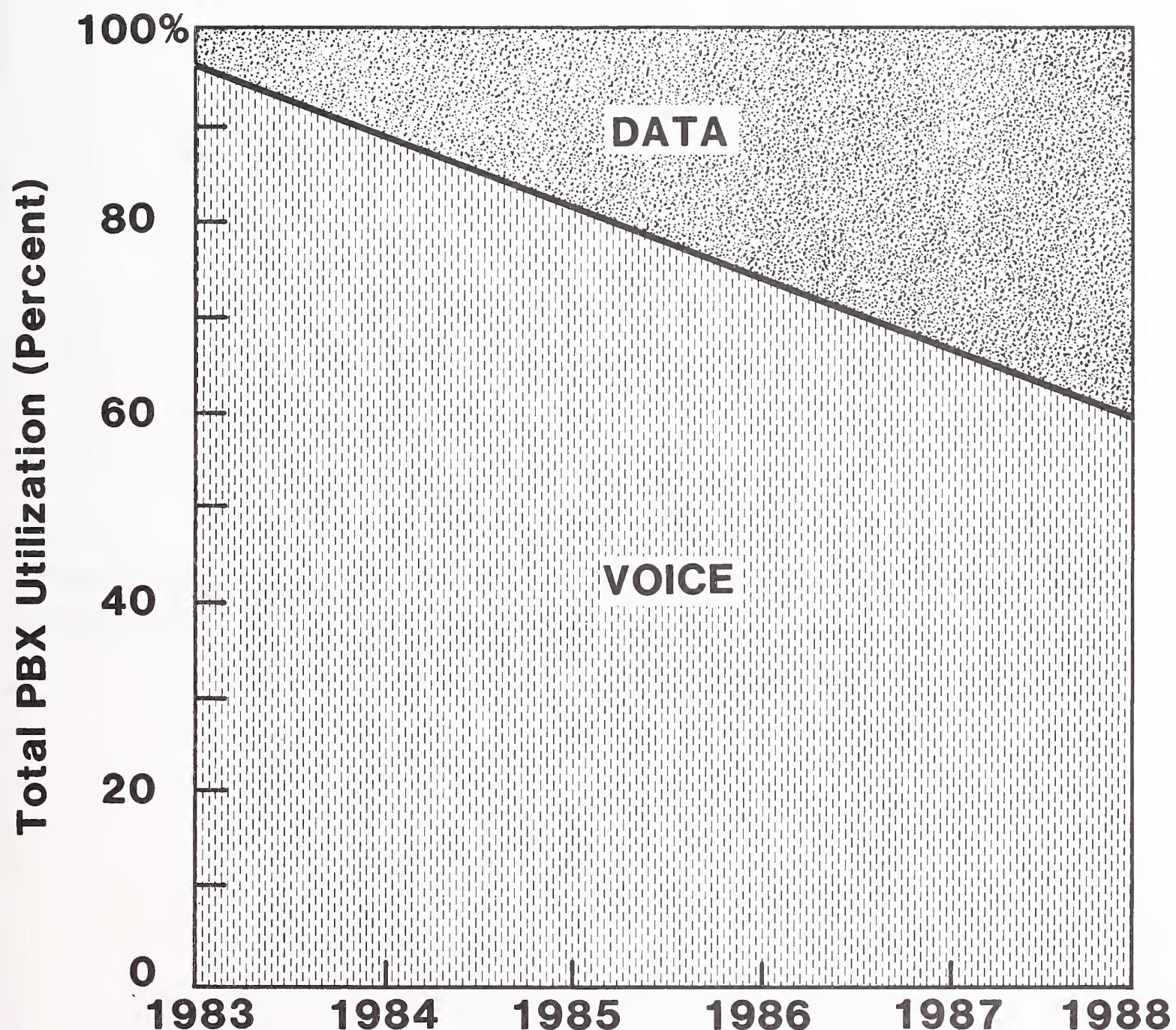
II EXECUTIVE SUMMARY

- This executive summary is designed in a presentation format in order to:
 - Help the busy reader quickly review key research findings.
 - Provide an executive presentation and script that facilitates group communications.
- The key points of the entire report are summarized in Exhibits II-1 through II-6. On the left-hand page facing each exhibit is a script explaining the exhibit's contents.

A. THE PBX MARKET IS IN A STATE OF MAJOR TRANSITION

- PBX companies have been suffering from gross margin erosion brought on by industry "price wars."
- New markets have opened up for PBX suppliers, and the PBX switch will experience continued acceptance as the "controller" for the office of the future.
- The PBX market, in terms of annual shipments, was roughly \$3 billion in 1983. By 1988, this market is expected to grow to about \$3.4 billion, a modest 2.8% per year increase. However, the market for both low-end and high-end voice-data-integrated PBXs is rapidly increasing. In addition, the makeup of the market in terms of types of systems shipped is dramatically changing.
 - PBX products and systems are moving away from voice-only PBXs to much more sophisticated integrated voice/data products with full complements of ancillary office automation features and functions.
 - These new products are integrating various local area network capabilities and have the ability to interface with a wide variety of external networks and equipment.
 - There is a significant trend toward increased use of data communications versus voice as a percentage of total PBX system utilization. This bodes well for those PBX suppliers who have or will be including sophisticated data features in their products along with standard voice capabilities. Currently, data represents only about 2% of total PBX utilization across all systems. By 1988 this figure should be almost 40%.

THE PBX MARKET IS IN A STATE OF MAJOR TRANSITION



B. SYSTEMS, LINES, AND REVENUES ARE ALL GROWING RAPIDLY

- U.S. PBX system shipments are estimated to have been 28,000 in 1983. By 1990 they will grow to 45,800, a 10.3% per-year growth.
 - Line shipments are projected to increase from 3.4 million in 1983 to 5.1 million in 1988, for an 8.2% per-year growth.
 - U.S. PBX revenues are expected to increase from \$2.95 billion in 1983 to \$3.39 billion in 1988, a 2.8% per-year increase.
- The above revenues do not include Centrex, key systems and "feature phones," voice/data workstations/terminals, ancillary applications, and enhanced software. The "under 100 lines" category and the "500 lines and above" category growth rates are significantly better than the overall market.
 - Revenues in the "under 100 lines" category are estimated to be increasing at a 9.2% per year rate, while revenues in the "500 lines and above" category are seen to be increasing at a 6.4% per year rate.
 - Specific areas of the market such as multitenant services are expected to grow much faster than the market as a whole.
 - More sophisticated areas of the PBX marketplace served by third and fourth-generation voice/data PBXs offer solid opportunities for growth and profitability.

SYSTEMS, LINES, AND REVENUES ARE ALL GROWING RAPIDLY

	1983	1984	1985	1986	1987	1988	AAGR
Total System Shipments (Thousands)	28.0	31.5	33.7	36.7	41.6	45.8	10.3%
Total Lines Shipments (Thousands)	3,400	3,705	3,935	4,260	4,650	5,050	8.2%
Total Revenue (\$ Millions)	\$2,950	\$3,009	\$3,080	\$3,180	\$3,285	\$3,385	2.8%

C. THERE ARE NEW OPPORTUNITIES FOR PBX GROWTH

- Requirements for new business communications and data processing equipment services associated with office automation have created the need for sophisticated integrated voice/data PBX systems.
- "Open" systems architecture will be typical, especially in the larger systems, as users will need to interface with a variety of diverse equipment systems.
- In addition to the requirement of developing integrated voice/data office systems and PBXs, there will also be an important need to establish user requirements and support channels to service user needs.
- The relative market shares for data lines will probably be shifting significantly over the next few years as the major manufacturers rapidly upgrade their systems to include significantly more sophisticated data communications capabilities.

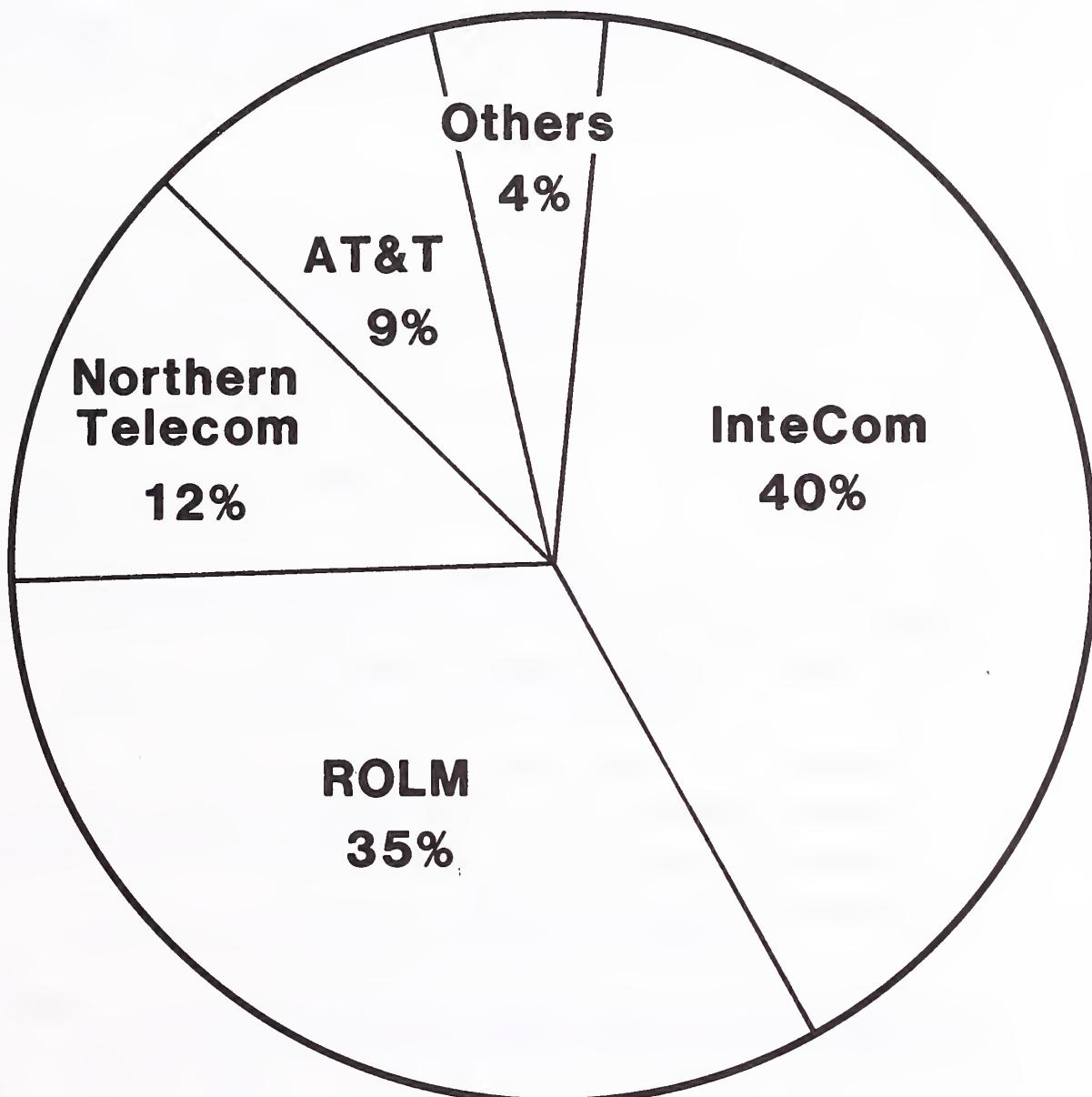
THERE ARE NEW OPPORTUNITIES FOR PBX GROWTH

- **Divestiture of (RBOCs) Will Create Exciting New Avenues for PBX Distribution**
- **RBOCs Are Planning to use PBX Products from Non-AT&T Suppliers**
- **RBOCs**
- **The Window of Availability for Obtaining RBOC Channels of Distribution Will Not Last Indefinitely**
- **Even the Later Entrants Will Have a Chance at RBOC Business**

D. THE PBX MARKET IS DOMINATED BY TWO GIANTS

- Exhibit II-4 presents an estimate of market share by manufacturer for the data portion of the PBX market (voice/data PBXs with lines installed for data applications as well as standard voice operation).
 - InteCom's high estimated market share results from the fact that its IBX system is very heavily oriented toward large data communications applications.
 - Even though ROLM shipped considerably more systems in 1983 than InteCom, InteCom's average line size was over 2000 lines, whereas ROLM's was closer to 250 lines.
 - ROLM systems were typically sold into environments with significantly less data communications requirements than those associated with InteCom installations.
 - Northern Telecom's percentage of data line market is significantly smaller than ROLM's since ROLM's CBX and CBX II systems generally have been better suited to data applications than Northern Telecom's SL-I.
 - As ROLM, Northern Telecom, and ATT-IS/ROBCs develop more competitive data communications capabilities, InteCom's market share in the data line area will shrink somewhat and will become more in line with its share of the overall PBX market.
 - Nevertheless, InteCom will continue to sell large systems with heavy data communications application content, and thus it should remain a major player in the data communications segment of the market.

THE PBX MARKET IS DOMINATED BY TWO GIANTS



1983

Total = 33,300 Data Lines Shipped

E. THE SHAKEOUT WILL CONTINUE

- In addition to the RBOCs, interconnect companies continue to offer channels of distribution for existing and emerging PBX suppliers. With the creation of ROBCs, however, the interconnects will face increasing competition and pricing pressures and many of the lesser interconnects will probably fail over the next one to two years.
- The independent telephone companies will also continue to offer channels of distribution that can be pursued by non-AT&T PBX suppliers. Because of the continued pricing pressures in the industry and the overall intense competitive nature of the PBX market, there may be a continuation of the shakeout. Companies that do not provide innovative, sophisticated voice/data PBX systems will not survive.
- Many companies, however, will be successful in capitalizing on the tremendous opportunities afforded by the growth in integrated office systems and the need for companies to improve worker productivity.
 - Emergence of sophisticated voice/data workstations, sophisticated software enhancements, and new office automation applications will provide PBX suppliers with sizable incremental revenues beyond those generated by basic PBX products.
 - Close OEM/joint development associations between PBX suppliers and computer manufacturers are becoming common.
- Vertical and specialty application market niches are becoming more and more attractive and profitable for PBX suppliers. InteCom's success in the multitenant market is a good example.

THE SHAKEOUT WILL CONTINUE

- Pricing Pressure Will Increase**

- Shakeout Will Include:**

- Independent Telcos**
- Interconnect Companies**

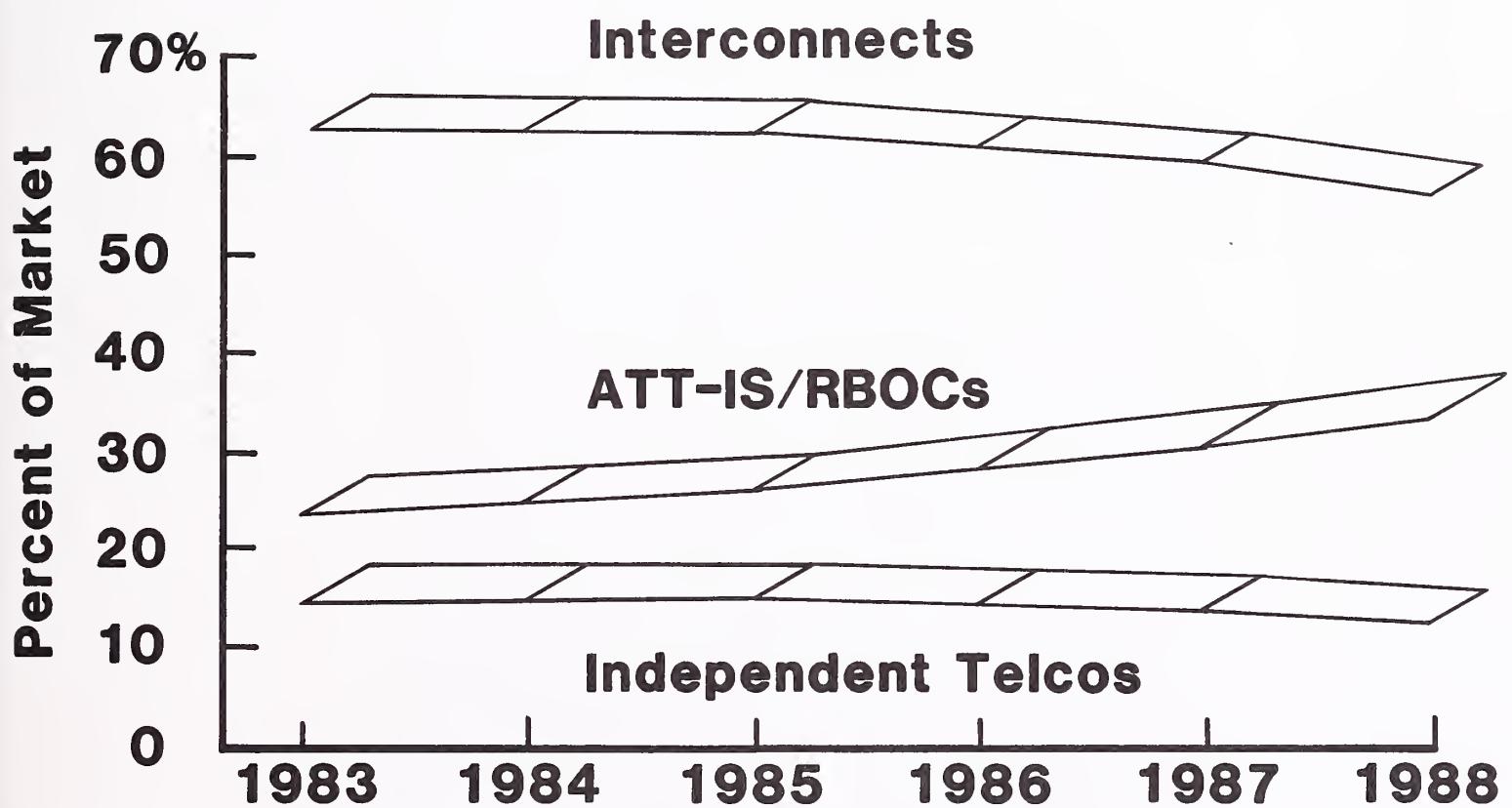
- Survivors Will:**

- Provide Voice/Data PBXs**
- Exploit Integrated Office Systems Growth**
- Participate in Joint Development with PBX and Computer Manufacturers**

F. THE PHONE COMPANIES ARE BECOMING PBX CHANNELS OF DISTRIBUTION

- ATT-IS and the RBOCs will be increasing their percentage of the total PBX market from 24% in 1983 to 33% in 1988. This increase relates to the fact that many major suppliers such as InteCom and Northern Telecom will increasingly use the RBOCs as primary channels of distribution for their products. ATT-IS will be providing more competitive products (both AT&T-manufactured and non-AT&T manufactured) over this period.
- The independent Telephone Companies are expected to remain roughly flat in terms of their percentage of the market between 1983 and 1988, declining only slightly over that period from 14% to 12% of the total market.
- The interconnect companies are expected to lose some market share (62% in 1983, going to 55% in 1988) based on the projection that the RBOCs and ATT-IS will provide increasingly attractive distribution channels for equipment manufacturers. As a corollary to this trend, expect a shakeout of many of the marginal interconnect companies between now and 1988.

THE PHONE COMPANIES ARE BECOMING PBX CHANNELS OF DISTRIBUTION



III TECHNOLOGY REVIEW/ANALYSIS

III TECHNOLOGY REVIEW/ANALYSIS

A. INTRODUCTION

- Beginning January 1, 1984, the newly divested Bell Operating Companies, organized into seven Regional Bell Operating Companies (RBOCs), were authorized to market customer premises equipment (such as PBXs) in direct competition with AT&T Information Systems (ATT-IS).
 - Both the RBOCs and ATT-IS can now sell as well as lease telecommunications equipment.
 - This is a departure from the historical arrangement whereby such equipment offered by the Bell Systems was available only on a lease or rental basis and was under FCC or state Public Utility Commission regulation.
- With the severing of the relationship between the Bell Operating Companies and AT&T, and the creation of ATT-IS as an unregulated arm of AT&T, non-AT&T suppliers (the so-called interconnect companies) can now market their products to the RBOCs and to ATT-IS (as well as the independent Telephone Companies), as was the case prior to the Modified Final Judgement and the January 1, 1984 divestiture.

- The additional market opportunities afforded by the divested RBOCs and the creation of ATT-IS will provide a major stimulus to the sale of telecommunications equipment by non-AT&T suppliers.
 - Previously, the Bell Operating Companies were reliant almost exclusively on AT&T (with equipment manufactured by Western Electric) for the acquisition of their PBX equipment.
- Traditionally, AT&T's PBX equipment has not kept pace with advances in technology and related new features provided by manufacturers such as ROLM, Northern Telecom, Mitel, InteCom, and others.
 - Consequently, the RBOCs are now aggressively looking at non-AT&T suppliers and have already established agreements with several equipment manufacturers.
 - The newly divested RBOCs are making every effort to be competitive with ATT-IS as well as the interconnect companies.

B. EVOLUTION OF THE MODERN PBX

I. PBXs VERSUS LANs

- The modern PBX has evolved dramatically over the past few years. Only a short time ago the PBX was used almost exclusively for voice communications. Gradually, somewhat unsophisticated data communications capabilities were added so that low-speed data terminals could switch data calls from one phone or place to another. Thus, it became possible to transmit and receive data over a single instrument (e.g., the Data-phone).

- This function was of marginal benefit to the PBX users but opened the doors to much more sophisticated data applications now available in state-of-the-art PBX products.
- With the emergence of local area networks (LANs), PBX vendors have provided very sophisticated LAN-type capabilities as an integral part of their PBX products.
 - As a result, the earlier function of voice communications, while still the essence of most PBX products, has been augmented dramatically with a number of data communications and office automation capabilities ranging from electronic mail to wideband data communications interfaces to mainframe computers.
- New PBX companies such as Prolink, CXC, and Ztel are emphasizing distributed PBX functions built around a LAN approach to integrated voice/data communications.
 - In addition, the major, traditional PBX suppliers such as ROLM and Northern Telecom, have also moved aggressively into the more sophisticated, LAN-type PBX architectures.
 - ROLM's "Gateway" (providing non-IBM terminal access to IBM computer systems) and Northern Telecom's "OPEN World" (providing interface standards for connecting dissimilar equipment) are major system concepts built around distributed, multi-functional PBX-based systems providing access, through the PBX, to a wide variety of computer systems and office automation equipment.
 - InteCom, the first PBX supplier to provide a truly sophisticated integrated voice/data PBX, offers its LANmark system to address the office automation requirements of today's users.

- For the past few years there has been a heated controversy regarding the extent to which modern PBXs would play a major role in office automation, as opposed to the emerging local area network (LAN) systems.
 - The PBX advocates have held that the PBX approach to office automation has advantages in terms of installation, ease of voice/data integration, reliability, and cost.
 - LAN advocates have emphasized the distinct LAN advantage of high bandwidth and its related very high transmission speeds for applications such as video conferencing and computer-to-computer communications where the 56-64 Kbps limit of most third-generation PBXs will not suffice.
- With enhancements to the third-generation PBX products and the emergence of fourth-generation PBXs, the distinctions between a purely PBX solution versus a purely LAN solution are blurring considerably. A more detailed discussion of these distinctions appears in Chapter IV.
 - The current thinking relative to office automation design is that the modern PBX and the emerging LAN technologies will co-exist and be integrated into an optimum system configuration where the best features of the PBX's switching capabilities and the LAN's high-speed transmission capabilities can be achieved.
 - As a result, the latest emphasis is how to best marry PBX and LAN technologies to achieve the optimum total system performance and cost objectives.
- This increasing need to develop a totally integrated office system employing both the latest PBX technology as well as the latest LAN advances, places a great burden on suppliers as well as corporate users, who, in many cases, must be the "prime contractor" in putting all the pieces together into a unified system.

- The PBX suppliers who are able to develop the technical sophistication and product marketing awareness necessary to provide the required system interfaces to the LAN world, as well as external packet networks, satellite facilities, and other sophisticated communications systems and services, will have a distinct advantage over their competitors.
- As the technology develops, a single-function, standalone PBX product will suffer in the marketplace because of user demands for increasing integration of their various office functions.

2. INTEGRATED OFFICE SYSTEMS

- It appears obvious, regardless of the specific applications involved, that PBX vendors must view their product as an integral element in the office systems environment.
 - Without an understanding of diverse, integrated office automation requirements and computer systems interfaces, tomorrow's PBX vendors will find themselves hard-pressed to compete.
 - The distinction between workstations, computer systems, communications networks and voice telephone switches are becoming so blurred that a product that does not envision the integration of these functions will soon be of limited interest to most major corporations.
- Enlightened corporate information systems planners addressing office automation issues are striving to incorporate the functions of communications processing, user workstations, local area networks and other related computer and communications processors and peripherals into an integrated, mutually compatible information system.

- The new PBXs, in order to be truly competitive, must offer features such as fully integrated voice/data switching; speed, code and protocol conversion for data transmission; administrative management capabilities; interfaces to TI and other wideband communications facilities; interfaces to data processing equipment; interfaces to local area networks; packet switch networks and store-and-forward message switching systems; and gateway functions allowing various office systems to interface with one another.
- Many users will not require the comprehensive sophistication offered by the new PBXs and, for the next few years, will still be primarily involved with voice and very little data communication.
 - For these users, PBX systems that are extremely modular and expandable in architecture will be very attractive.
 - Users with limited data and other office automation requirements will ideally start out with a small, voice-oriented system that can be later upgraded to include, on a modular basis, any needed enhanced features that may be required down the road.

3. ANALOG VERSUS DIGITAL

- In 1981, roughly 90% of the PBXs manufactured were analog; by 1990 this figure will be less than 5%.
 - This shift from analog to digital PBXs is being fueled by the rapid growth in digital trunks throughout the telephone network.
 - As digital trunks replace analog trunks in the network, the cost and maintenance logistics of interfacing the analog switch to a predominantly digital network will become prohibitive.

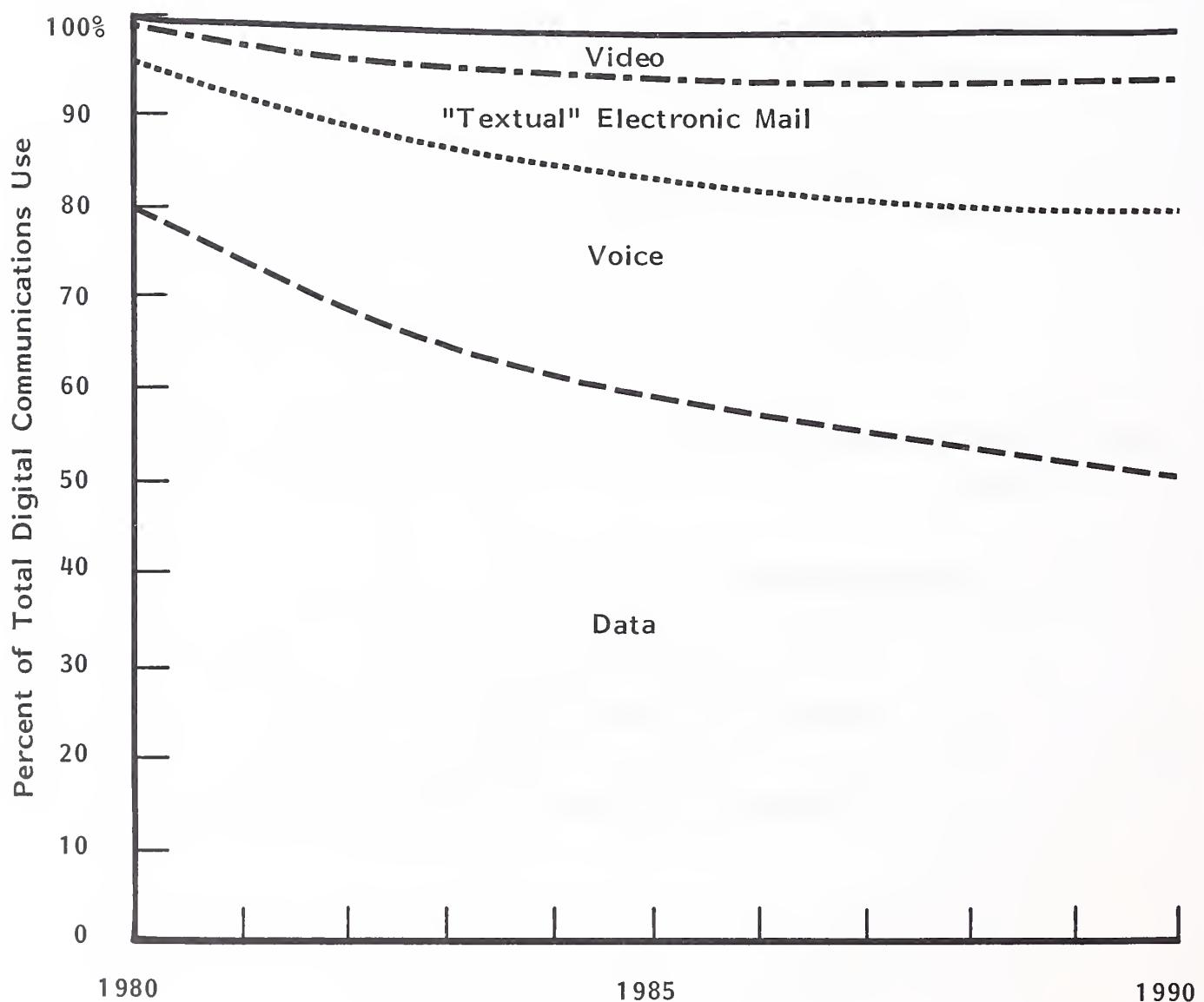
- An additional impetus in the growth of digital versus analog switches is the lower cost per line of digital switches.
- Additionally, the added functionality of the new digital switches and the integration of these systems into expanded sophisticated office automation environments will make analog switches unacceptable.
- Exhibit III-1 breaks down digital communications use by its major applications areas, for a ten-year period from 1980 to 1990.

4. PBX GENERATIONS

- The evolution of modern PBX systems and the existing distinctions among systems as regards technical capabilities may be defined by means of assigning "generations" to various products.
 - These somewhat simplistic distinctions, however, are rapidly disappearing as older products are being upgraded with new technology.
 - Most PBX manufacturers resist being pigeonholed into a specific generation and prefer to focus on system features and capabilities.
- The PBX generations, as most commonly discussed today, may be defined as follows:
 - First Generation
 - . First-generation PBXs include electromechanical, crossbar, and electronic crosspoint systems.
 - . These types of PBX systems are now considered obsolete.

EXHIBIT III-1

DIGITAL COMMUNICATIONS USE BY MAJOR APPLICATION
1980-1990



- Second Generation
 - . These systems were the first of the so-called intelligent PBXs incorporating stored program control (software driven).
 - . Both space division switching (analog) and pulse amplitude modulation/time division multiplexing (digital) systems fall into this category.
 - . Second-generation PBXs do not provide significant data-switching capability. Only analog trunks are supported.
- Third/Fourth Generation
 - . The distinctions between third- and fourth-generation PBXs have really become more a matter of degree than actual functional difference.
 - . For the most part, fourth-generation PBXs differ most significantly from third-generation systems in that the fourth-generation is more highly modular and distributed.
 - . Third- and fourth-generation PBXs are digital in nature, even though analog is supported (see below).
 - . They also use stored program control and have extensive data switching capabilities.
 - . PBXs in this category generally employ pulse code modulation/time division multiplexing and are much more heavily oriented toward software features than are second-generation PBXs.

- Both analog and digital trunks are supported, as well as standard analog telephone instruments or digital "feature phones."
 - Sophisticated voice/data workstations can be accommodated in third and fourth-generation, but not in first or second.
 - High-speed, multiplexed trunk interfaces to T-1 carrier facilities are provided, as are interfaces to LANs and mainframe computers.
 - Applications such as voice store-and-forward and electronic mail are supported.
 - Traffic is nonblocking or "essentially nonblocking."
- Third- and fourth-generation PBXs have three basic characteristics:
 - A nonblocking switching matrix.
 - A distributed architecture.
 - Integrated voice and data switching.
- The nonblocking approach uses a fixed-time slot for each port.
 - This fixed-time slot allocation lends itself to improved control processor performance since it eliminates the complex hardware and software previously required to make time slot assignments.
 - In addition, a nonblocking switch is preferable to a blocking system in that the control processor overhead needed to support such ancillary processors as those used for voice store-and-forward and electronic mail is reduced.

- PBXs with distributed architecture connect the central switch to remote or distributed switching nodes via fiber optic or coaxial cable, as opposed to twisted-pair wiring.
 - In the case of a distributed PBX system, the distributed switching node has the capability to handle some of the central PBX's processor workload.
 - The system design complexities are significant in distributed PBX systems; however, the gains in flexibility, reliability, and cost savings associated with distributed architecture in many cases justifies the added complexity.
- True integrated voice and data indicates that the PBX design is able to handle voice and data on an equal basis without separate transmission paths, sub-multiplexing schemes, alternate-use ports, dedicated voice and data ports, or doubling up of ports required when both voice and data are handled. The third-generation PBXs support simultaneous data and voice transmission with data rates up to 64 Kbps.
- A third-generation PBX operates basically as a circuit-switched transport network that connects the user to a variety of communications systems and features such as computers, voice recognition equipment, electronic mail systems, and voice store-and-forward systems. Other functions, such as protocol conversion, and code and speed conversion, may also be provided in third-generation PBXs like the InteCom IBX.
- With AT&T's divestiture of the RBOCs, billions of dollars worth of second-generation PBXs will be available for purchase.
 - While these PBXs do not offer the sophisticated features described above for the third- and fourth-generation systems, many users will be

able to handle their communications requirements with these older systems.

- If the price is right, and if no sophisticated office automation requirements are envisioned for several years, purchase of the older systems could very well make sense.
- Most large companies, however, would more than likely be limiting themselves by purchasing second-generation products.

5. HIGHER DATA TRANSFER RATES

- While the data handling capability of third-generation PBXs might seem adequate at a level of 56-64 Kbps, current high-powered workstations with high-resolution displays (Xerox's Star) and process-sharing systems (Apollo Computer's Domain and Three Rivers Computer Corporation's PERQ) employ even higher data transfer rates.
 - Consequently, a higher speed transmission link, such as offered with LAN systems, is a legitimate requirement that needs to be addressed in total system design involving these types of new sophisticated workstations.
 - Some PBX vendors, for example, ATT-IS, GTE, and Northern Telecom, have addressed this higher transmission speed requirement by providing data compression protocols that reduce the high-output data rate from the sophisticated workstations and terminals down to the 56-64 Kbps range that is acceptable to the PBX.
 - Also, the third- and fourth-generation PBX vendors are able to offer specialized channels that can switch data up to 1 Mbps when supported by standard twisted-pair wiring.

- If data rates above 1 Mbps are required, the LAN approach is generally preferable to the PBX. In particular, specialized services such as video benefit from the high transmission rates provided by LANs.
- Today's system designers are looking for ways to combine the PBX and LAN technologies into an optimally integrated total system, as opposed to choosing between one or the other.

6. PBX VENDORS OFFERING LANs

- An example of a new PBX that incorporates the best features of conventional voice/data switching as well as LAN capabilities is the NEC NEAX 2400.
 - The NEAX 2400 is an easily expandable system, including a local area network (LAN) module that allows the user to extend the system operation to multiple offices and interface with a variety of office automation systems and external public and private communications networks.
 - With the addition of the LAN capability, the NEAX 2400 provides the ability to configure a total network that integrates voice, data, text, and video applications.
 - The NEAX 2400 utilizes a combination of twisted-pair and fiber optic cable in various loop configurations.
- LAN implementations are also offered by InteCom, Ztel, and CXC, among others.
 - InteCom offers the LANmark local area network product as an adjunct to its IBX. LANmark supports the Ethernet LAN protocols.

- Ztel manufactures a fourth-generation PBX, Private Network Exchange (PNX), which includes a LAN product consisting of a token ring network carrying voice, data, and video simultaneously. The PBX architecture provides for several rings, each of which can operate at 10 Mbps.
- CXC's fourth-generation PBX, the Rose, is based on a broadband LAN distributed concept where up to 64 system nodes can be interconnected.

7. NEW MICROPROCESSOR TECHNOLOGY

- New microprocessor technology has improved reliability and flexibility in modern PBXs. In the past, users were forced to choose between a PBX employing a nonvolatile but relatively inflexible EPROM-based system configuration, or a PBX based on readily alterable but highly volatile RAM technology.
- With the advent of EEPROM (electrically erasable programmable read-only memory) technology, however, PBXs may now be designed with the best features of EPROM and RAM, and without the associated disadvantages.
 - An EEPROM such as the SEEQ Corporation 52B13 not only supports an easily modifiable system configuration, but also protects it from electrical or mechanical failures.
 - It is now no longer necessary for a PBX user to return EEPROMs to the supplier for rebuilding each time a station, trunk, or systems parameter is changed; nor is it any longer necessary for a user to worry about power outages or surges destroying a configuration programmed into RAM or problems with inputting faulty data from backup tapes into RAM.

- One of the first digital PBXs to offer an EEPROM-based system configuration feature was the Harris Digital Telephone System's DI200 product line.
 - The DI200 uses the SEEQ 52B13 EEPROM chip and Harris proprietary software, which allows for user-programmable moves as well as system diagnostics.
 - The DI200 is an example of how advances in microprocessor technology are impacting the PBX marketplace.

8. SUPER PABXs/CBXs--VOICE/DATA INTEGRATION

- The new integrated voice data Private Automatic Branch Exchange (PABX) systems combine digital computer data with digitized voice data. A typical example of this new integrated PBX product is the LDX system from United Technologies/Lexar.
 - In this system, a microprocessor in the telephone set encodes and decodes voice data at 56 Kbps. The telephone set is also equipped with an RS-232-C interface, which can be connected to computers or terminal devices.
 - The digital computer or terminal data, along with the digitized voice and voice signaling data, are combined in the telephone set microprocessor and arranged in 10-bit packets. These packets are transmitted between the telephone set and PABX at a data rate of 8,000 packets per second.
 - This configuration can support voice at 56 Kbps and full-duplex asynchronous data at speeds up to 9600 bps. This is accomplished over a single pair of wires. A second pair of wires provides power to the telephone set.

- This integrated voice/data arrangement provides advantages over separate voice and data systems.
 - It provides a cost-effective method for supporting both voice and data over a single pair of wires.
 - In addition, this system allows any telephone set to become an access point for computers or data terminals without requiring data modems.
- Protocol conversion is another capability of the new voice/data PABXs.
 - For example, InteCom offers a capability whereby low-cost asynchronous CRT displays may be connected via the PABX to an IBM computer that emulates more expensive IBM 3270 display devices.
 - In this configuration, the low-cost CRT terminals communicate between the PABX and the IBM computer in a bisynchronous data link protocol and operate in a functionally equivalent mode to a clustered 3270 configuration--the PABX functioning as the 3270 cluster controller.
- The true cost-effectiveness of InteCom's approach is, of course, dependent on the number of terminals involved. The added capability and associated cost for protocol conversion must be prorated across the total number of terminals to determine true cost-effectiveness.
- Manufacturers of integrated voice/data PABXs are generally finding that users have not developed clear-cut applications for full voice and data integration.
 - Consequently, the suppliers of these powerful new PABX systems are endeavoring to market their products in the voice communications arena to establish product credibility and a customer base upon which to build future, more sophisticated voice/data business.

- Vendors such as InteCom, Datapoint, and Lexar have discovered that users place heavy emphasis on efficient handling of standard voice communications prior to expanding system capability to incorporate more sophisticated data communications capabilities, facimile transmission, and teleconferencing.

C. SATELLITE COMMUNICATIONS

I. INTRODUCTION

- The satellite communications industry, embroiled for 15-plus years in political controversy, is developing into a multibillion-dollar industry during the 1980s. The industry is substantially altering the way Americans are entertained and the way business conducts its affairs.
- Worldwide revenues for commercial telecommunications via satellite have risen to approximately \$1 billion (total invested capital) by the end of 1983, a compound annual growth rate of over 19%. Satellite spacecraft sales alone are expected to total at least \$1.5 billion in the next five years.
- The effects of satellite communications on consumers will become most noticeable in home entertainment. The communications satellite is forging thousands of local cable television operators into a single entertainment network, opening an enormous market and challenging the three major networks for dominance of mass television communications.
- Other beneficiaries of this explosive growth will be suppliers of small earth stations and direct broadcast satellite systems.

- For U.S. satellite common carriers, entrance into the market has been, and will remain, costly. It is estimated that participants have invested in capital equipment, or spent through operating losses, at least \$1 billion by the end of 1983; the total will continue to escalate. The future for satellite communications is constrained somewhat by the number of available orbital slots.
 - At the present time, satellites in the 4-6 GHz band are spaced four degrees apart and satellites in the 12-14 GHz , three degrees apart. The FCC is currently looking at the feasibility of two degrees spacing.
 - While slots are still available under the current rules, long-term transponder capacity demands will, no doubt, necessitate higher frequently transmission and closer satellite spacing.
- Satellite technology offers significant advantages over other forms of transmission:
 - The cost of satellite channels is independent of channel distance.
 - Satellite transmission has the benefit of broad transmission (broadcast) capability so that any single satellite transmission can be received by multiple earth stations.
 - There is a rapidly accelerating trend toward reduction in the size and cost of satellite earth stations, with added intelligence being incorporated into the satellites themselves.
 - The speed at which this trend develops will dictate in large part the extent to which satellite communications will replace conventional terrestrial circuit technology.
 - In spite of the rapid technological improvements resulting in lower satellite earth station costs, the shorter-distance circuits will continue

to be served by more conventional technologies and the newer fiber-optic technologies throughout the 1980s. A cost-per-channel diagram is shown in Exhibit III-2, where costs are equated to length of transmission. Exhibits III-3 and III-4 equate the potential costs over the number of channels required, first for Time Division Multiplexing (TDM), and then for Frequency Modulated (FM) signals.

- The primary impact for satellite transmission will be on long-distance routes where major cost savings are achieved.
- In addition, there will be many applications for broadcast transmission where satellite communications will have a distinct advantage over other competing technologies. An example of this type of broadcast application is stock market quotation services.
- As is the case with Dataphone Digital Service (DDS), satellite transmission once received by an earth station still must be extended to the customer premises, providing these premises are not co-located with the earth station. Throughout the 1980s, these local extensions typically will be conventional analog circuits or DDSs where available.
- The communications system designer throughout the 1980s will have a wide variety of transmission and equipment options with which to build communications systems. No one technology will have in every case obvious advantages over the others. This applies to satellite transmission as well as to all others.
- At present, there are 15 U.S. satellite systems in operation and supplied by four major carriers--Western Union, RCA, COMSAT General, and SBS.
 - Twelve new satellites have been authorized and will become operational by the mid-1980s.

EXHIBIT III-2

COST PER CHANNEL PER MONTH VERSUS CHANNEL LENGTH
(Channel Capacity = 1,800 Channels)

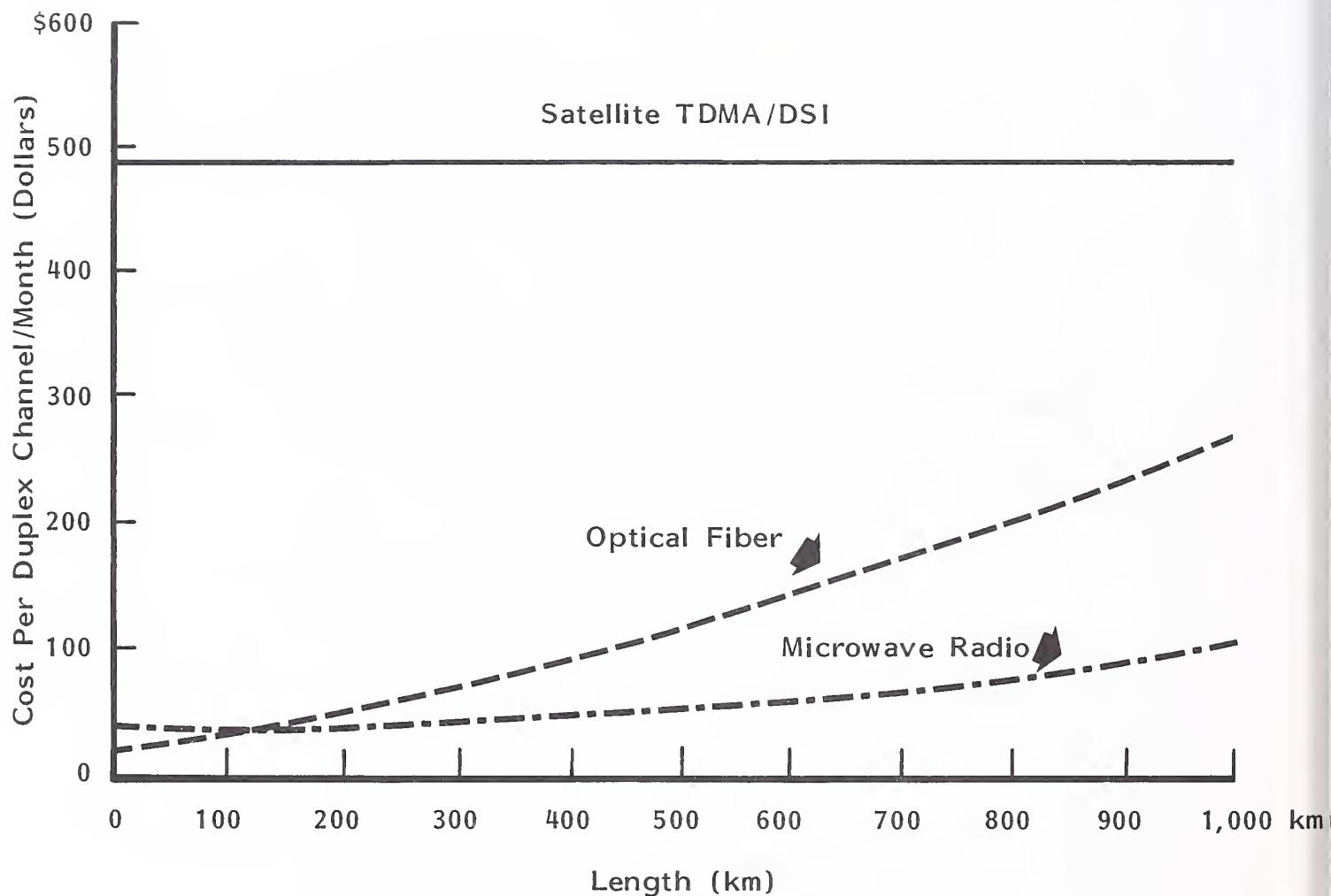


EXHIBIT III-3

TYPICAL SATELLITE COSTS USING TDMA

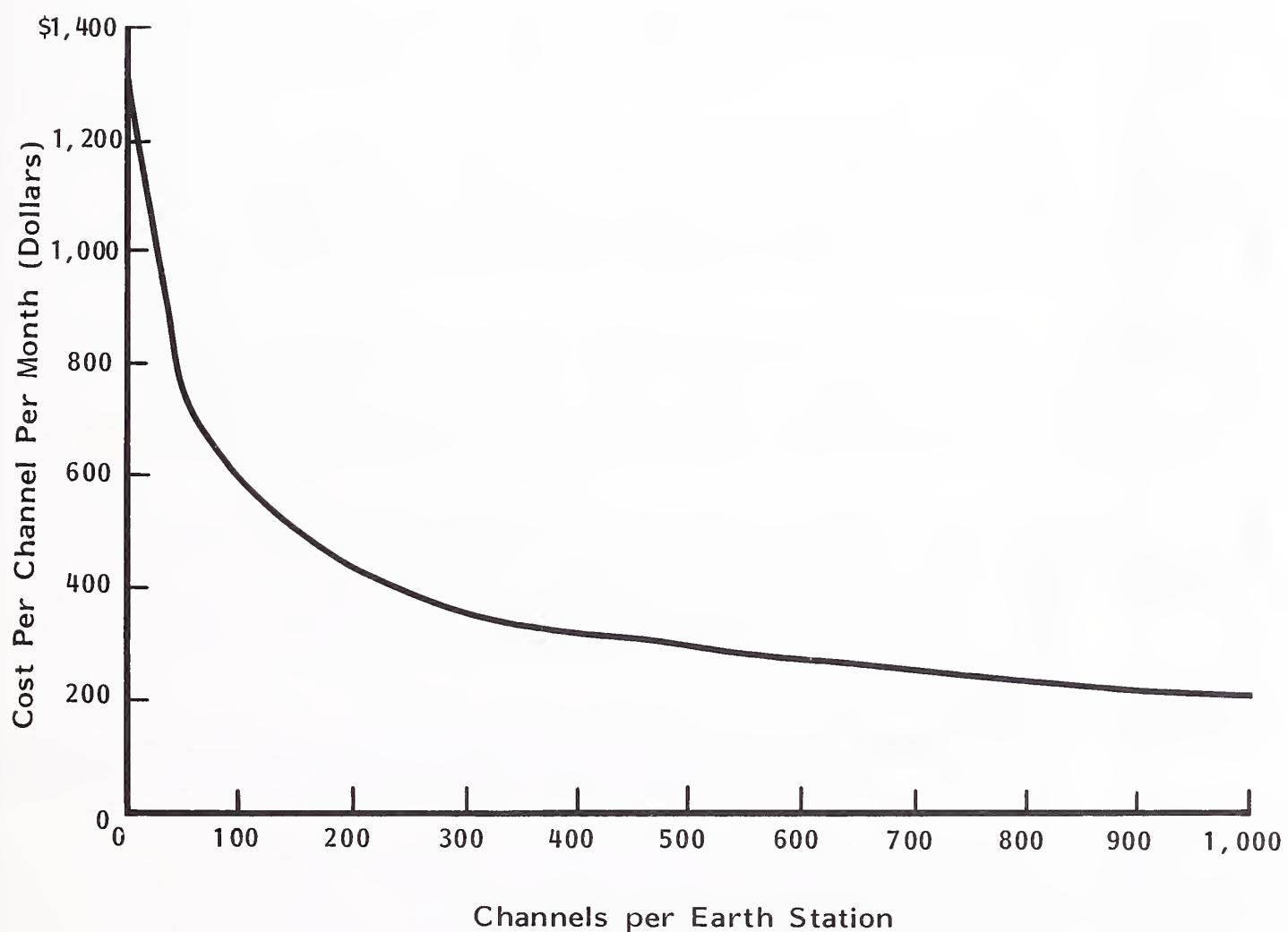
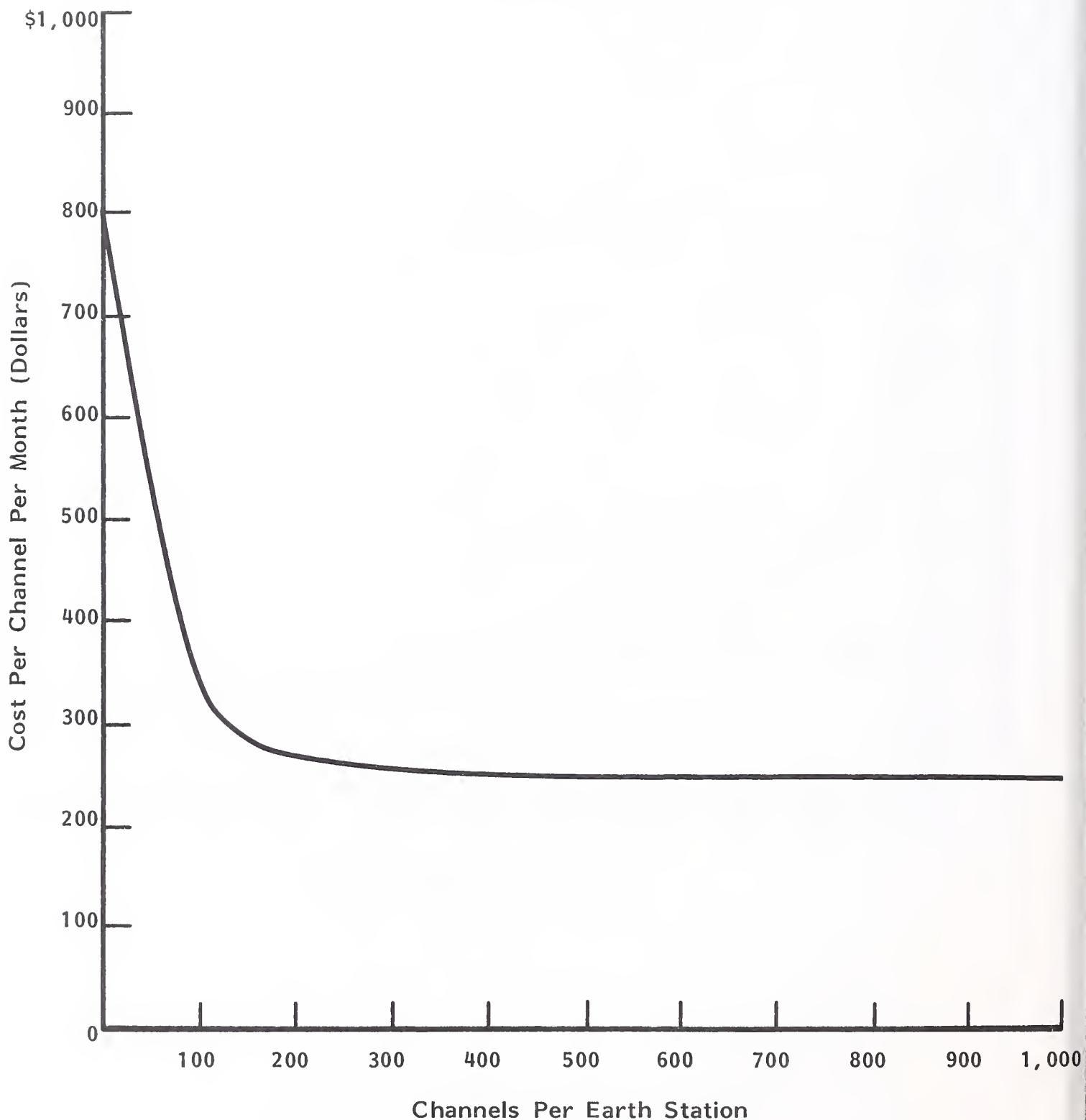


EXHIBIT III-4

TYPICAL SATELLITE COSTS USING FM



- Three new carriers have entered the satellite arena--Hughes, AT&T, and GTE.
- Over and above these satellites, several military satellites and scientific satellites are also operational and planned.
- Because of the increased satellite channel demands, higher and higher frequencies are being required to provide the necessary additional capacity without associated interference.
 - Up until 1980, communication satellites operating above North America employed six and four GHz.
 - By 1985, a number of them will be operating as high as 14 GHz. Because of bandwidth crowding, it is becoming necessary to develop satellites operating at even higher frequencies, such as 30 and 40 GHz.
- There is a strong movement toward the direct broadcast of television from satellites to home antennas. This trend is creating a new industry with new technology being developed to provide low-cost antennas for home use.
- Competition in the satellite communications industry can be separated into four categories--Domestic Common Carriers, International Common Carriers, Spacecraft Suppliers, and Satellite Earth Station Suppliers.
- COMSAT is owned by private investors and is engaged in international satellite communications only.
 - TelSat Canada and INTELSAT are owned entirely by government sources or authorized representatives but are not part of the public telephone and telegraph (PTT) system.

- Other nations (e.g., Indonesia) purchase and operate satellites through their PTTs.
- The five U.S. spacecraft suppliers are Hughes Aircraft Company, Ford, TRW, RCA, and General Electric.
 - TRW currently specializes primarily in military satellites.
 - TRW and G.E. are, however, starting to focus on direct broadcast satellites, as opposed to military satellites.
 - Hughes will be pressed for leadership by Ford, but most of Ford's efforts are concentrated in military applications.
 - It requires considerable expertise and investment to participate in the spacecraft business, and because of the high costs involved, there will likely be no new entries into the field. RCA and General Electric may well drop out.
- There are currently five domestic common carriers authorized by the FCC: American Satellite Corporation, RCA Americom, Satellite Business Systems (SBS), COMSAT General, and Western Union. AT&T has been authorized as a satellite communications carrier, and has recently put its first satellite in orbit. The battle for communications service dollars will soon focus on AT&T and SBS as they position themselves to capture the large business communications users.

2. TRANSPONDERS

- A significant issue relating to satellite communications involves the selling of transponder capacity as opposed to offering channels on a leased tariffed basis. The FCC is currently investigating domestic satellite suppliers who are engaging in sales of transponder capacity in lieu of tariffed channels to

determine the extent to which this practice is in the public interest and to establish appropriate FCC approval procedures.

- Western Union, RCA, American Communications, and Hughes Communications have notified the FCC that they plan to sell portions of their transponders on a "non-common carrier" basis.
- In today's satellite marketplace, space segment capacity for a private satellite network will be difficult to obtain.
 - For the foreseeable future there will be a severe shortage of transponder capacity.
 - Cable television (CATV) will use up available capacity rapidly.
- The first generation of domestic satellites is beginning to be replaced.
 - The FCC has authorized construction and launch of replacement satellites in addition to several new satellites.
 - Currently, all available orbital locations for satellites are assigned in the four and six GHz band.
 - Assignments in the 12 and 14 GHz band are totally allocated at the present time.
- In the past, customers requiring transponder capacity have leased it from common carriers.
 - These leasing arrangements have involved tariff pricing.
 - Space capacity has been assigned on a first-come, first-served basis.

- The leasing arrangements between customers and satellite suppliers have been rather arbitrary. For example, the RCA auction in the fall of 1981 of Satcom IV satellite transponders created serious controversy. The FCC, as noted above, declared the auction invalid and rejected RCA's tariff since bidders received the same transponder but at different prices.
- Similar creative arrangements have been developed to meet customer requirements by other satellite carriers. Several large corporations have reached agreements with the major satellite carriers to purchase transponders prior to satellite launch.
 - While such procurement of transponder capacity may very well be an appropriate business decision, such sales have not been approved by the FCC.
 - Eventually, sales transactions will be authorized by the FCC. Indeed, the FCC recently began a Notice of Capital Inquiry proceeding to consider these types of sale transactions.
- Earth station facilities naturally are closely linked to transponder capacity. Earth stations and satellite capacity can be obtained as a package from a satellite carrier.
 - In this case the carrier installs, owns, operates, and licenses the total system.
 - The customer pays for the total satellite service offered under the carrier's tariff.
 - Alternatively, earth station facilities could be owned, operated, and licensed by a company as private facilities.

- Transmit/receive earth station facilities are covered under Title III of the Communications Act.
 - Receive-only earth stations, however, are presently deregulated and may be licensed at the customer's option.
 - The customer must perform frequency coordination for each earth station site in cases where earth station facilities are licensed as private facilities.
- The market for satellite transponder capacity is expected to remain volatile for the foreseeable future. There are no set rules for acquiring satellite capacity and it will be some time before clear-cut standards are established.
- Since satellite network excess capacity can be resold, at present resellers of satellite network capacity are regulated as common carriers. Consequently, authority must be obtained from the FCC before resale of excess capacity can occur. This assumes there is excess capacity to offer for sale.

D. FIBER OPTICS

I. INTRODUCTION

- By far the most promising approach to lightwave communications is the fiber-optic system.
 - The major fiber-optic components include the emitter, which transforms electrical pulses into light pulses; the fiber or optical waveguide, which guides the light; and the detector, which converts the light pulses back into electrical pulses. Connectors and couplers are also involved.

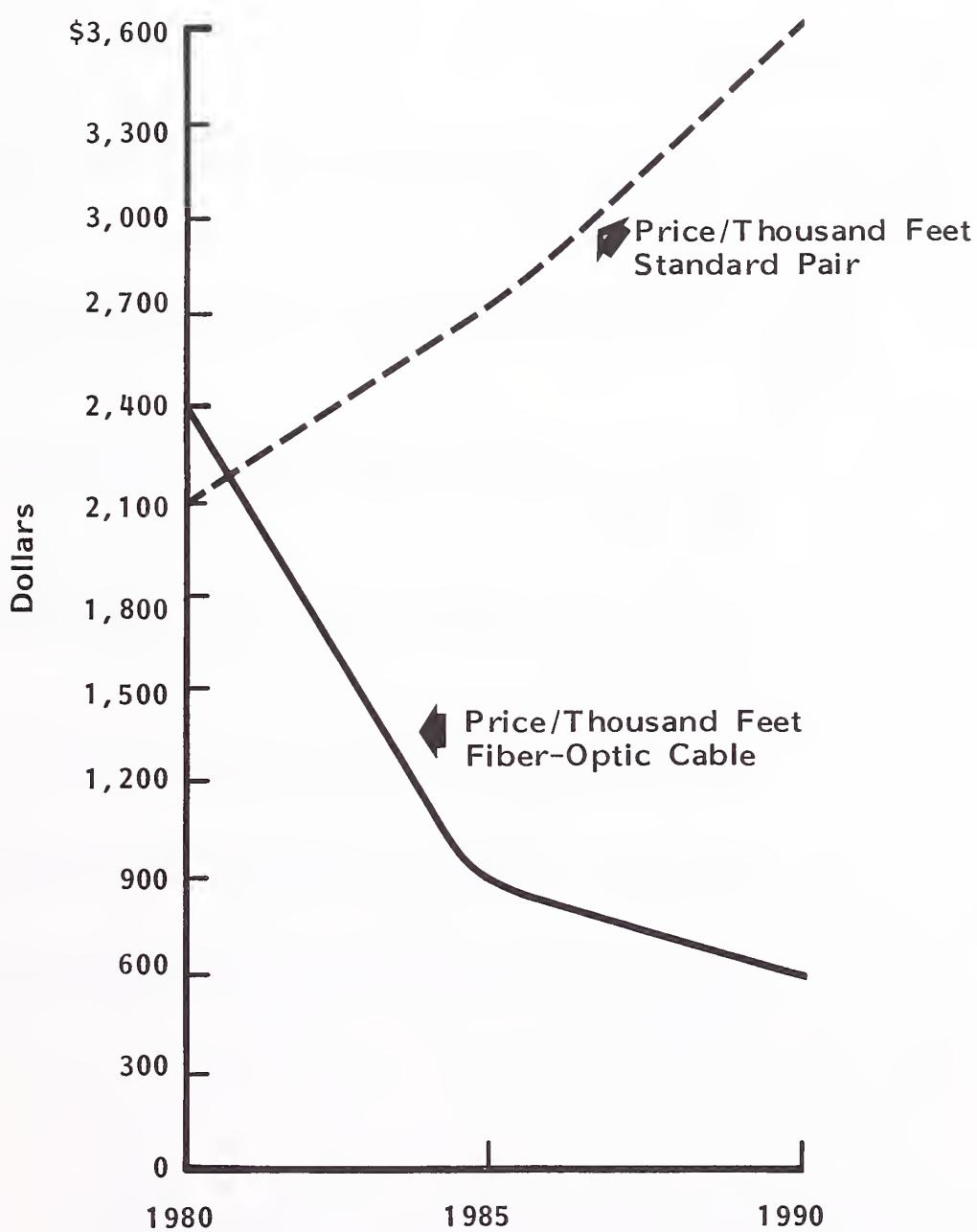
- The emitter and the detector are parts of the transmitter, repeater, and receiver modules.

2. TECHNOLOGY

- The traditional alternatives to fiber-optic transmission are twisted-pair wire and coaxial cable. These comparative costs are shown in Exhibit III-5.
- Fiber-optic systems offer considerable advantages over their traditional copper-based counterparts as noted below:
 - . Higher information capacity.
 - . Smaller size and weight.
 - . Fewer signal losses.
 - . Immunity to electromotive induction (EMI) and radio frequency interference (RFI).
 - . Greater Security.
 - . Safety.
- The main disadvantages of fiber-optic systems are that they have short lifetimes and are currently more expensive to manufacture than are copper wires. However, significant improvements in both areas are expected in the next five years. System lifetimes are currently as slow as one to two years, but may be high as forty years by 1990.
- The cost, when measured on a per-channel-km basis, is already significantly below that of conventional systems. Costs, measured in dollars

EXHIBIT III-5

FIBER CABLE VERSUS TWISTED-PAIR COPPER PRICES
1980-1990



per millions of bits per second (Mbps) are illustrated in Exhibit III-6. Exhibit III-7 shows how costs stabilize as distance increases.

- With the price of copper as volatile as it has been in recent years, fiber-optic systems will appear even more worthwhile in the future.
- Fiber-optics costs for rural and suburban areas are compared in Exhibit III-8.

3. TYPES OF COMPETITORS

- As is often the case in a newly emerging technology, competitors range from the very large to the very small.
 - Generally speaking, manufacturers can be sorted into the following five groups:
 - Integrated Suppliers--manufacture all components of a fiber-optic system.
 - System Houses--concentrate on system design and may do some manufacturing.
 - Fiber Manufacturers--limit themselves to production of fibers.
 - Electronics Companies--manufacture emitter and diodes.
 - Wire and cable companies--manufacture cable but not complete systems.

EXHIBIT III-6

TYPICAL FIBER OPTIC COSTS

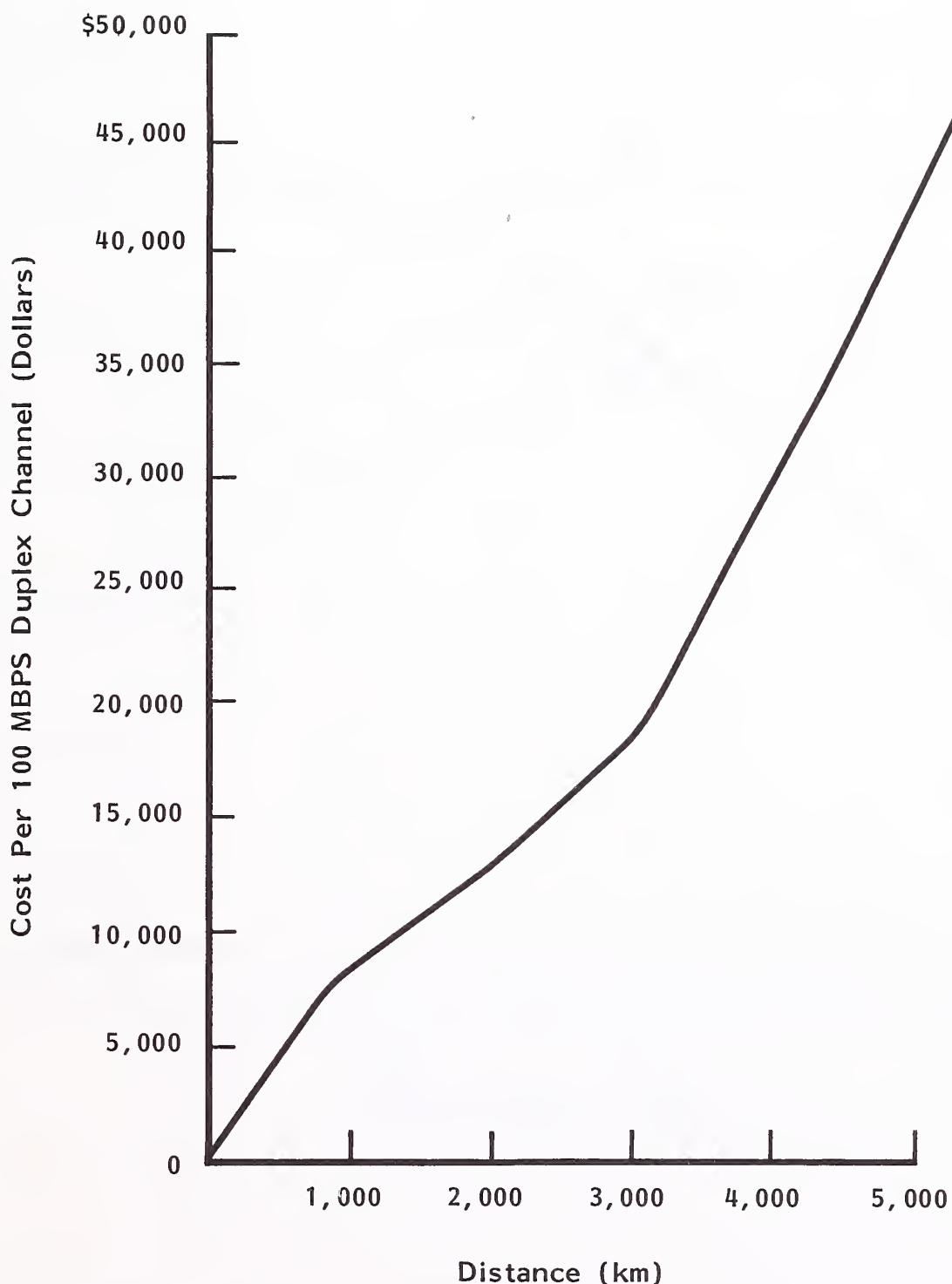


EXHIBIT III-7

OPTICAL FIBER COST VERSUS CAPACITY (MBPS)

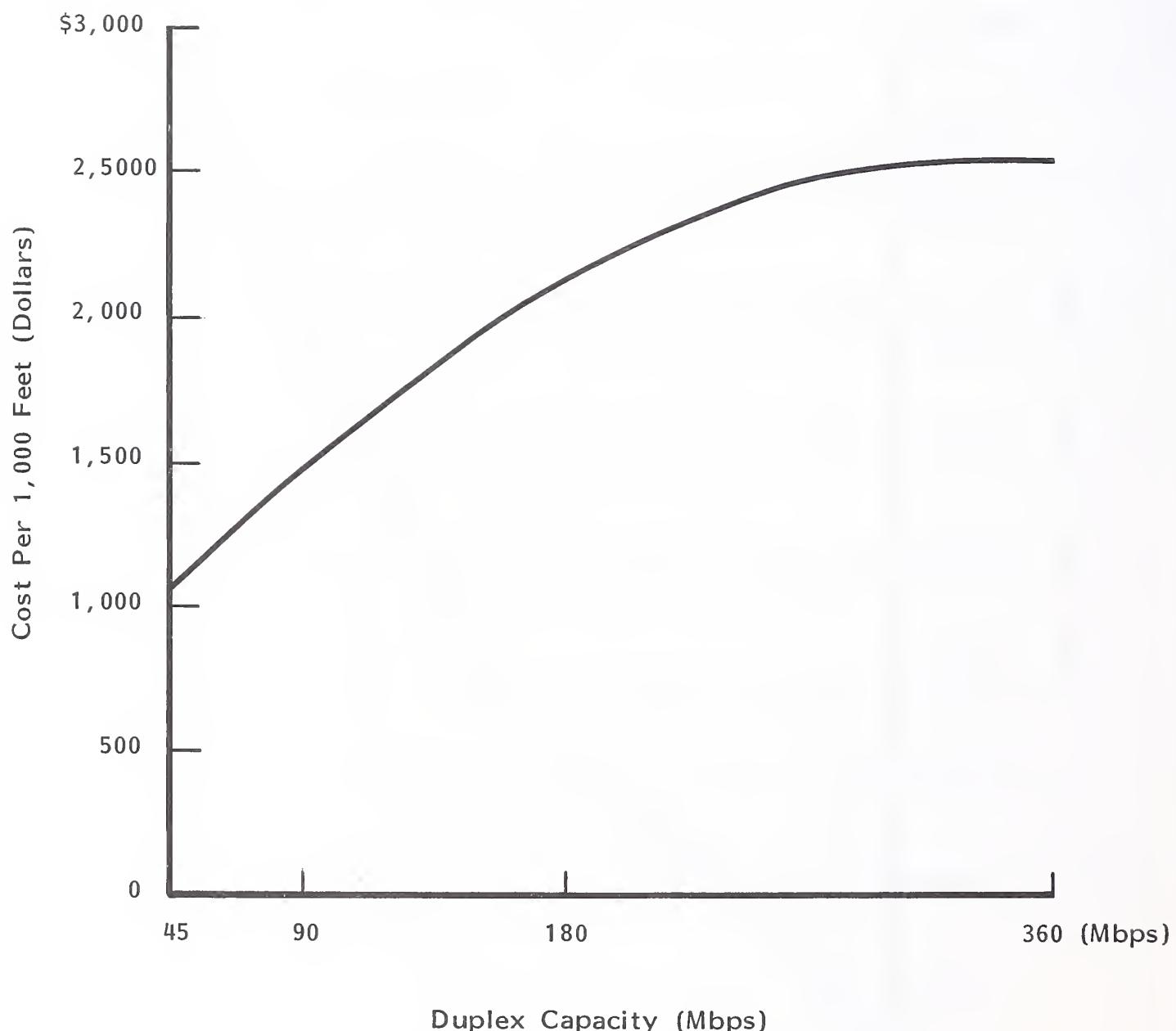
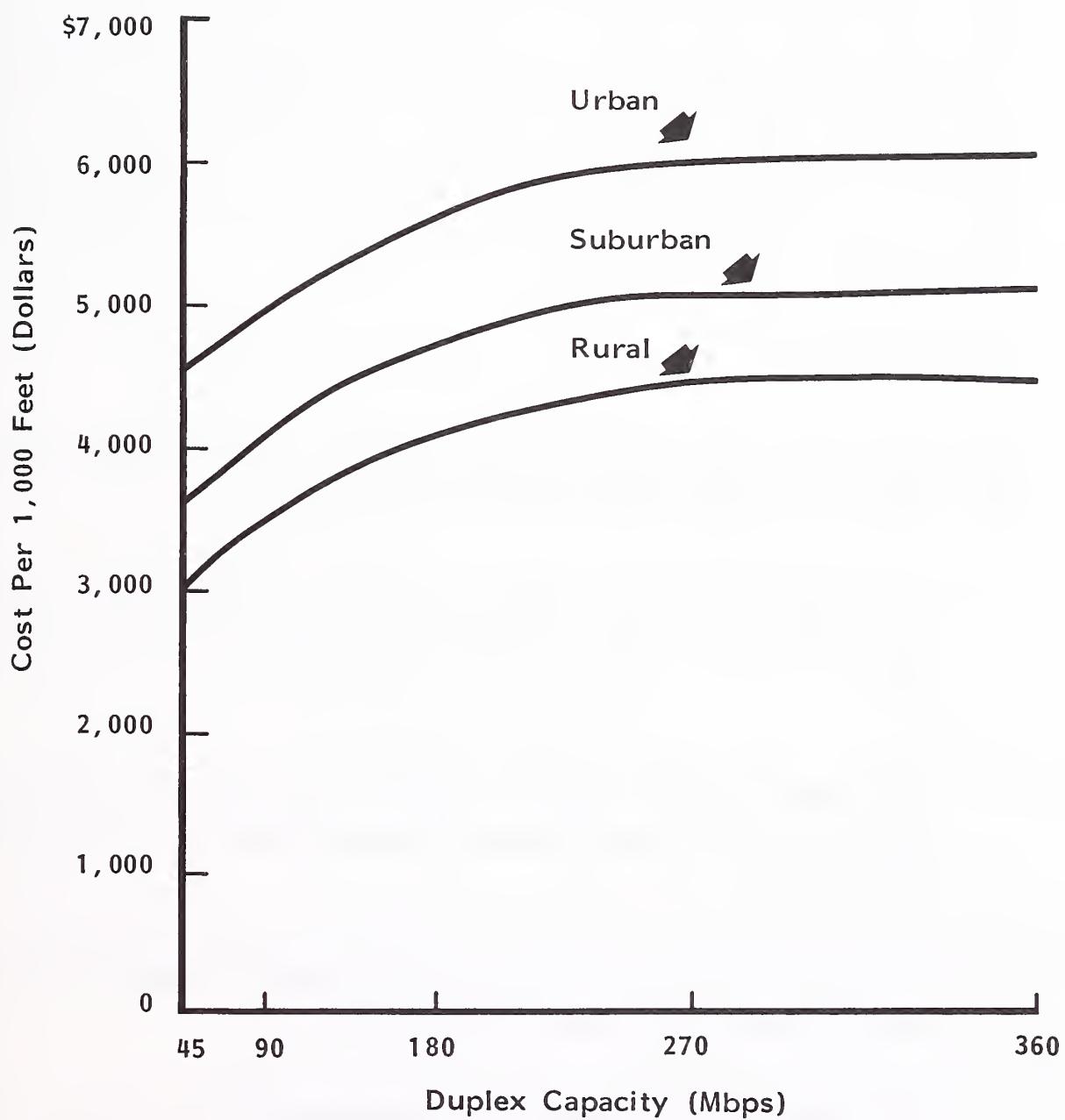


EXHIBIT III-8

OPTICAL FIBER COSTS
(Including Installation)



E. LEASES

I. INTRODUCTION

- Semiconductor lasers, or laser diodes, are constructed in the same way as light-emitting diodes (LEDs) except that the epitaxial layers have an index of refraction lower than the active region in order to form an optical cavity. The active region is less than 1 nm thick and the edges of the substrate, or facets, are highly polished. The emitted light is contained within the cavity and stimulates other energy-level transitions until all of the light rays are oriented in the same direction and the device emits the highly coherent light. A stripe contact is used to limit the number of lateral modes that can be generated.

2. TECHNOLOGY

- The problems with semiconductor lasers have been that they tend to have short lifetimes and their output is temperature sensitive.
 - Lasers now on test have lifetimes in excess of 20,000 hours; 100,000 hours will be the required lifetime for telecommunications applications.
 - The temperature dependence is in the form of decreased output for a given drive current at high temperatures, and increased output at low temperatures.
 - If the output is allowed to get too high, it will blow one of the facets and thus destroy the resonant optical cavity.
 - One method of compensating for temperature fluctuations is to monitor the output with a PIN detector that looks at the back facet.

The output of this detector can be used to change the drive current to produce a constant power output level.

- Considerable progress has been made during the last five years in laser diode performance.
 - In particular, lifetime, power output, linearity, radiation pattern, and efficiency have all been significantly increased.
 - These improvements are the result of a number of factors:
 - Better materials.
 - More precise processing controls.
 - Understanding the failure mechanisms.
 - Improved packaging, especially better heat sinking from the junction.
 - Controlled factory production, with documented procedures.
 - Improved quality control.
 - Further laser diode cost/performance improvements will result from future efforts in these same areas.
- Another emitter type with significant potential is the nonsemiconductor laser. It is the oldest source technology, but also the least developed.
 - The nonsemiconductor's potential is enormous, given its intense, narrow-focused beam and high bandwidth.

- Unfortunately, it is unreliable and has a very short lifetime (1,000 hours). Also, nonsemiconductor lasers suitable for fiber-optic applications will remain low in power output.
 - Other nonsemiconductor lasers are capable of higher outputs, but their dimensions are too large for optical fibers.
- Although lasers of either type still require significant characterization and development work, they will eventually be the first and only choice for extremely long-haul, high-bandwidth applications.
- One recently developed emitter known as the side-emitting or superluminescence diode (SLD) exhibits both spontaneous (as in an LED) and stimulated (as in a laser) light emissions. It has a narrower spectral width and a higher radiance than an LED, and favors low-order modes like a laser. However, efficiencies are still lower than those of lasers in general.
- Another new emitter is the mode-locked, color-center laser developed at Bell Labs. This laser consists of a single crystal color-center pumped by a nonsemiconductor laser. The primary selling point of this tunable, high-wavelength laser is a fast pulse rate.

F. MICROWAVE

I. INTRODUCTION

- Major trends occurring in the microwave industry are:
 - A shift from analog to digital technology.

- Replacement of older multiplex equipment with so-called "high-density" multiplex equipment based on LSI technology.
- Introduction of significantly improved "self diagnostics" as an integral part of the newer multiplex and microwave transmission equipment.
- A move toward more and higher frequency allocations (e.g., 18 and 23 GHz bands).
- Use of microwave to replace local Bell loops (the so-called Digital Termination Service--DTS--in the 10.6 GHz band).
- Economic projections, based upon past performance, show that microwave revenues should more than triple from 1980 to 1990. The numbers are shown in Exhibit III-9.

2. TECHNOLOGY

- Total bandwidth over a microwave route is typically subdivided into groups of voice-grade circuits, as follows:

<u>Group Designation</u>	<u>Number of Voice-Grade Channels</u>
Group	12
Super Group	60
Master Group	300
Super Master Group	900
Radio	2,700

- All or any portion of a radio group may be multiplexed to derive individual channels.

EXHIBIT III-9

THE MICROWAVE MARKET

MICROWAVE RADIO EQUIPMENT	REVENUES (\$ Millions)		
	1980	1985	1990
<u>U.S.</u>			
Analog	\$175	\$150	\$100
Digital	75	275	500
Totals	\$250	\$425	\$600
<u>REST OF THE WORLD</u>			
Analog	\$450	\$350	\$250
Digital	50	450	950
Totals	\$500	\$800	\$1,200
<u>GRAND TOTALS</u>			
Analog	\$625	\$500	\$350
Digital	125	725	1,450
Totals	\$750	\$1,225	\$1,800
<u>MICROWAVE MULTIPLEX EQUIPMENT</u>			
<u>U.S.</u>			
Analog	\$300	\$250	\$170
Digital	125	460	850
Totals	\$425	\$710	\$1,020
<u>REST OF THE WORLD</u>			
Analog	\$550	\$500	\$400
Digital	200	700	1,600
Totals	\$750	\$1,200	\$2,000
<u>GRAND TOTALS</u>			
Analog	\$850	\$750	\$570
Digital	325	1,160	2,450
Totals	\$1,175	\$1,910	\$3,020

- The microwave market by major application is examined in Exhibit III-10; Exhibit III-11 shows the market breakdown by supplier.
- Total worldwide microwave revenues for the 10-year period 1980-1990 is plotted in Exhibit III-12. Note particularly the decline of analog and the steady rise in digital use.
 - While the maximum capacity of a radio group is 2700 voice-grade channels (as noted above), in practice something in the range of 1800-2200 voice-grade channels is set as an upper limit to avoid overdriving the system.
 - Overdriving results in noise and crosstalk.

3. DIGITAL MICROWAVE

- There is a strong trend to move from analog to digital microwave equipment.
 - Rockwell/Collins, Harris/Farinon, NEC, Ratheon, and Avantek are leading suppliers offering digital microwave equipment, as shown in Exhibit III-13. Note that the exhibit identifies these manufacturers of both analog and digital multiplexors (MUX), as well as identifying the microwave frequency assignments.
- Digital microwave frequencies above 4 and 6 GHz are currently available.
 - Frequencies have been allocated for commercial use in the 11, 18, 30 and 40 GHz range.
 - The advantage of these higher frequencies is that they provide additional microwave capacity in geographical areas already saturated with four- and six-GHz spectrum utilization.

EXHIBIT III-10

U.S. MICROWAVE EQUIPMENT MARKET
BY MAJOR APPLICATION

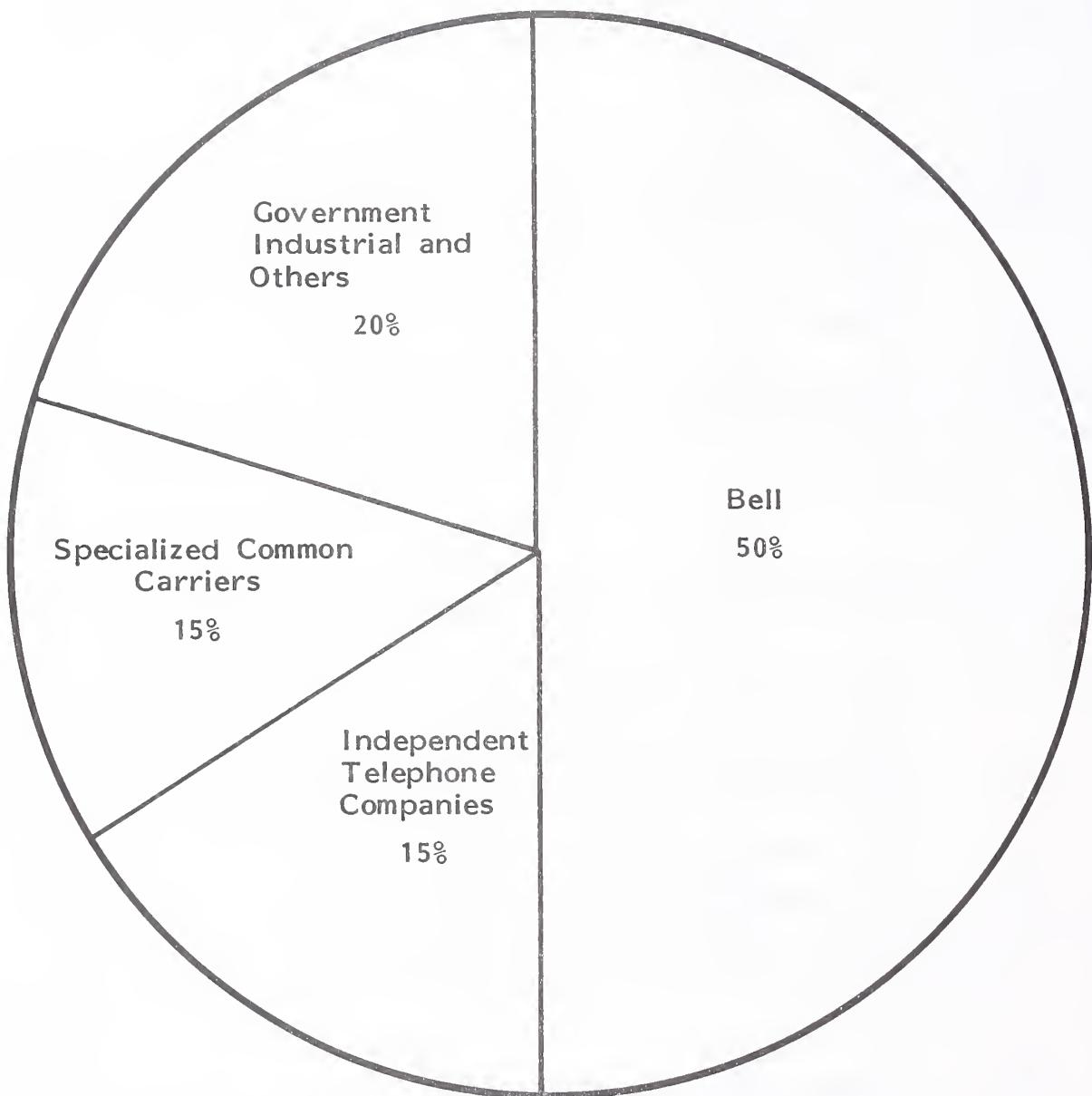


EXHIBIT III-11

**U.S. MICROWAVE EQUIPMENT MARKET
BY SUPPLIER**

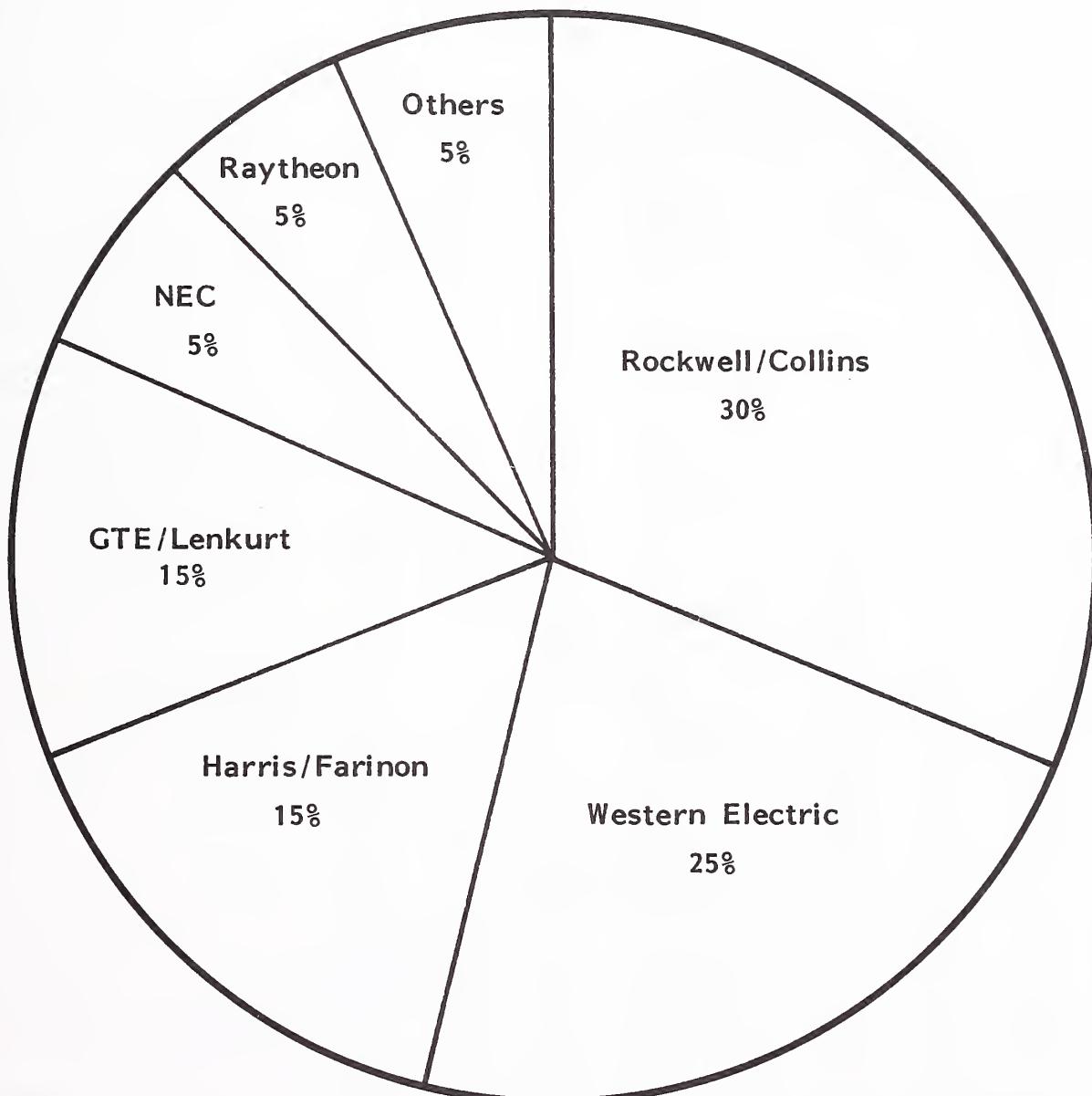


EXHIBIT III-12

WORLDWIDE MICROWAVE EQUIPMENT REVENUES
1980-1990

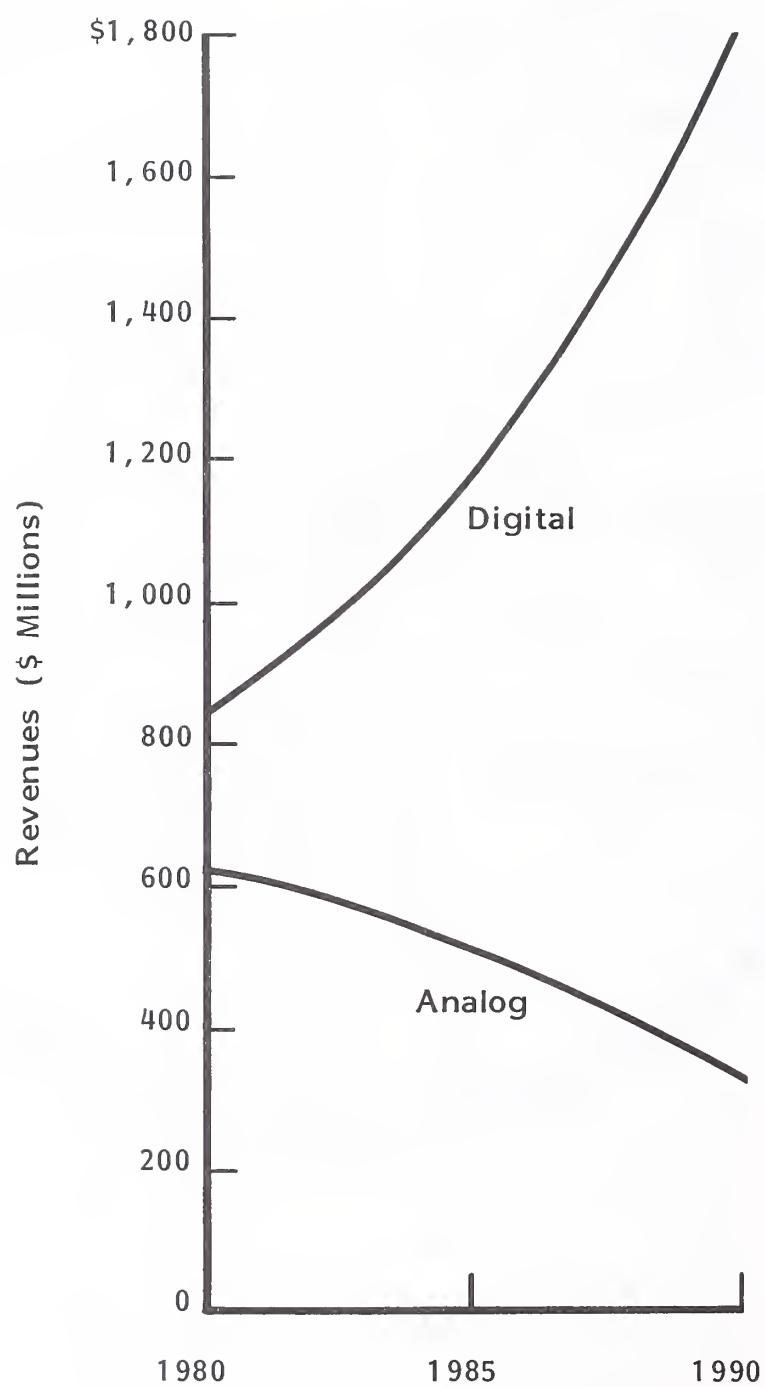


EXHIBIT III-13

MAJOR MICROWAVE EQUIPMENT MANUFACTURERS
(Outside the Bell System)

Manufacturer	PRODUCTS MANUFACTURED			
	Analog MUX	Digital MUX	2GHz Microwave	4-13GHz Microwave
Anaconda	--	--	--	--
Avantek	--	--	X	X
Harris/Farinon	X	X	X	X
GTE-Lenkurt	X	X	X	X
ITT/North Electric	X	X	--	X
Lynch	X	X	--	--
Microwave Associates	--	--	--	X
Motorola	X	--	X	X
NEC	X	X	X	X
Raytheon	--	--	--	X
Reliance	--	--	--	--
Rockwell/Collins	X	--	X	X
Seiscor (Raytheon)	--	--	--	--

- There are, however, significant disadvantages in the use of higher frequency digital microwaves.
 - These disadvantages relate primarily to increased cost for equipment, greater susceptibility to environmental conditions, and the need to regenerate the signal more frequently.
 - Four- and six-GHz systems require hops every twenty miles or so. Eleven-GHz systems require hops every ten miles. Thirty-GHz systems employ three-mile hops.
- While the analog market for analog equipment is certainly declining, the introduction of Western Electric's AR-6A analog system--an efficient system using single-sideband transmission and capable of handling as many as 6000 circuits--should significantly slow the conversion from analog to digital within the Bell System.
 - Bell expects to replace a high percentage of interstate analog microwave routes by 1985 with the more efficient AR-6A system.

4. IMPACT OF DIGITAL TERMINATION SERVICES

- With the FCC's announcement in 1981 to open up the 12-GHz band for direct broadcast satellites (see the satellite section of this report), a previously promising market for private microwave systems was substantially dampened and possibly eliminated.
 - Several equipment orders have been cancelled and applications to the FCC in the 12-GHz band withdrawn.
 - The FCC has ruled that users of such private systems will have to move from the 12-GHz band if the microwave transmissions interfere with direct-broadcast satellites.

- The FCC has offered the 18 and 23 GHz bands.
- These higher frequencies, however, involve more limited distances and, consequently, higher costs for a sufficient number of repeaters.
- In January, 1981, the FCC reallocated the 10.6 GHz band to digital termination service (DTS). MCI, SBS, and Tymnet (among others) provide local distribution facilities using microwave in direct competition to telephone company-provided local loop facilities.

G. INFRARED

- Another type of communications technology that has been utilized in the past and may have greater application in the 1980s is infrared transmission.
 - Infrared has advantages over other forms of short-haul communications: Specifically, relatively simple optical technology is required in the antenna, the receiver can be pole-mounted, the frequency spectrum utilized by infrared systems is not presently regulated, and commercially available infrared systems may be connected to terminals and computers via a standard Electronics Industry Association (EIA) interface.
 - The disadvantages of infrared systems are that they are limited to relatively short distances—in the order of 2000 feet—and systems are very susceptible to environmental conditions involving snow, rain, heavy dust conditions, etc.

H. CONCLUSIONS

- The divestiture by AT&T of the seven Regional Bell Operating Companies (RBOCs) has created a large new marketplace for non-AT&T manufacturers.
 - The RBOCs are becoming major distributors of non-AT&T products.
 - The high-end, large customer segment of the market will most likely be targeted by the RBOCs, given their present resource constraints and the lucrative nature of the high-end segment.
- Efficiencies of digital technology, burgeoning data communications requirements, and the increasing availability of digital transmission facilities have fueled the rapid growth of digital PBXs.
- Requirements for new business communications and data processing equipment and services associated with office automation have created the need for sophisticated integrated voice/data PBX systems. "Open" systems architectures will be typical, especially in the larger systems, as users will need to interface with a variety of diverse equipment.

IV ECONOMIC IMPACT/ANALYSIS

IV ECONOMIC IMPACT/ANALYSIS

- Note: Because retaining the continuity of the discussion is so important to understanding the following section, all exhibits have been moved to the end of the chapter. The exhibits also require some explanation, which further reinforces the decision to keep them together at the back of the section.

A. "EMBEDDED" PBX EQUIPMENT

- Beginning January 1, 1983, the Bell Operating Companies were prohibited by the FCC's Computer Inquiry II Decision from selling or installing any new single or multi-line telephone systems, including PBXs.
 - Such sales and installations of customer premises equipment have been made, since January 1, 1983, by AT&T Information Systems (ATT-IS).
 - In November 1983, the FCC implemented the second phase of its customer premises equipment plan by ordering the future deregulation of all so-called "embedded" Bell System PBX equipment (installed prior to January 1, 1983) and transferring ownership of that equipment to ATT-IS.
 - The FCC, at the same time, ordered that this "embedded" equipment be offered for sale to the Bell Operating Companies' former customers

at reasonable prices and that those customers wishing not to purchase the equipment not be subjected to unreasonably high-term increased rental costs.

- The recent FCC orders relating to "embedded" PBX equipment installed prior to January 1983 do not apply to the equipment of the independent Telephone Companies.
 - However, the FCC is considering action such that their equipment will most likely be removed from the regulated ratebase by 1987 in a manner similar to the deregulation of the RBOCs' PBX equipment base, as described above.
 - In the meantime, the independent telephone companies will begin offering their installed base of PBX equipment for sale as a result of deregulation programs initiated by state Public Utility Commissions or simply as a result of their own strategic business decisions.
- The entire embedded base of PBX and other multiline customer premises systems were detariffed and transferred to ATT-IS effective January 1, 1984 at an overall net book value of roughly \$10 billion.
 - ATT-IS is required to offer this equipment for sale to existing users at prices established by the FCC after first releasing these prices to the public.
 - Older generation systems, special systems, and systems not manufactured by AT&T will be offered for sale in late 1984 and into 1985, or earlier at the customer's request. These systems may be priced individually on a negotiated basis.
 - ATT-IS has two years in which to offer for sale all of its customer premises equipment, including PBXs.

- The FCC has limited ATT-IS's total revenue recovery from embedded equipment to an amount not to exceed the next book value of the products transferred, so that prices will not exceed reasonable levels.
 - This stipulation, however, will not necessarily hold sales prices of individual systems down, since ATT-IS may choose a strategy of discouraging sales in favor of retaining its installed base on a rental basis.
 - Under this strategy, ATT-IS could set sales prices very high, thereby discouraging purchases and encouraging continuation of rental agreements.
 - Thus, the total revenue recovery from sales would never exceed the total net book value since many systems, because of their high purchase prices, would not be sold.
- ATT-IS estimates that approximately 75% of the currently installed customer premises equipment including PBXs will be available for purchase by the end of 1984. ATT-IS is allowed to select which systems will be sold first and has decided to begin sales efforts with the most current product lines, including Dimension PBXs.
- Customers will not be required to purchase equipment currently installed.
 - However, there will also be no long-term protection against future increases in monthly equipment rental or maintenance rates.
 - In the short term, however, the FCC has provided some protection against excessive rental rate increases. For example, all multiline systems including PBXs previously covered under tariffed rental plans will continue to be rented by ATT-IS at the rate effective in December 1983.

- Once ATT-IS announces a particular product line as available for purchase, however, the rental protection will cease and ATT-IS will then be able to establish a uniform nationwide monthly rental charge.
 - This new nationwide rental charge, however, will be implemented on a phased basis. The new rates will begin at the time the first offering of sale for that particular product is made. At that time, customers will be required to pay a national minimum charge. This minimum charge will be increased gradually to the national lease rate in three equal rate increases separated by eight months.
 - Customers currently paying more than the initial national minimum, but less than the established national lease rate, will be moved up to the national lease in three or fewer steps, each step eight months apart.
- In addition to the above protections, the national rental rate on all customer premises equipment including PBXs will have a maximum level for the first two years of the higher of:
 - The median tariffed rate for all states in which the equipment was tariffed as of March 29, 1983, or
 - Seventy percent of the highest tariffed rate for any state as of March 29, 1983.
- After the two-year period of transition, ATT-IS will be able to rent equipment at whatever rates it chooses.
- The FCC has also attempted to protect the financial interests of customers who have entered into two-tier or other long-term contracts, as opposed to monthly rental arrangements with the Bell Operating Companies.

- Under two-tier contracts, the customer pays a higher monthly payment (Tier A) for a period of years (typically three to five) covering the major switch hardware and software, after which time the monthly rate is reduced significantly (Tier B) and consists primarily of system maintenance, support, and certain other "tariffed" items associated with the PBX.
- These two-tier contracts were entered into by customers on the assumption that they would have long-term protection against rate increases.
- However, as soon as the equipment under contract is offered for sale on a nationwide basis, ATT-IS will be able to raise maintenance charges under Tier B. These increases, however, must be implemented under the same guidelines used to establish monthly equipment rental rates.

- ATT-IS will offer a 90-day warranty on used PBX equipment.
 - In addition, financing programs will be available to customers. These programs will be comparable to those offered to new PBX customers.
 - ATT-IS will handle sales of embedded equipment as lease-to-purchase conversions.
 - Customers previously covered under a month-to-month rental plan will be offered used equipment at a discounted price below the price for comparable new equipment.
 - In addition, credits will be provided for each month that the equipment has been rented and in service, subsequent to the transfer of equipment to ATT-IS.

- These credits will apply from the date equipment is offered for sale to the time of purchase, with a maximum credit period of 15 months. The credit will probably be less than the total amount of rental payments.
- Maintenance contracts will be provided by ATT-IS for used and new customer premises equipment.

B. AT&T'S MIGRATION STRATEGY

- Because of the competition in the PBX market from the RBOCs and the interconnect companies, ATT-IS will, of necessity, look closely at generating new sales through replacement of its installed base of older systems.
 - In 1979, AT&T instituted a pricing strategy of raising prices on older PBX equipment in order to convince existing customers to replace the old PBXs with new equipment.
 - This AT&T migration strategy envisioned upgrading up to 80% of the older generation PBXs to new systems.
 - AT&T has increased the rates on older PBXs by as much as 70%.
 - The AT&T strategy has achieved its aims to a great extent. In states where the new, higher tariffs for old-generation PBXs have been approved, these products are being replaced at a rate of up to 30% per year.
 - This tremendous replacement rate has reduced the overall installed base of old-generation PBXs from roughly 70,000 to about 40,000 units.

- About 80% of the balance of the 40,000 old PBXs are likely candidates for replacement. Replacement of these old systems could occur at the rate of approximately 10,000 systems per year.
- In spite of the substantial competition in the PBX market provided by non-AT&T suppliers, ATT-IS should remain the largest supplier of PBX equipment for the foreseeable future.
 - This market leadership by AT&T will, to a great extent, be related to the fact that they already have a huge installed base of older PBX equipment.
 - As noted above, this equipment was deregulated, effective January 1, 1984. ATT-IS can now offer very attractive equipment replacement programs that allow their existing customers to upgrade from the older AT&T PBX systems to the new products, such as Dimension System 85.
 - ATT-IS offers upgrade credits to those customers who migrate from the older equipment to the new systems.
 - In addition, some of the hardware and other related equipment in the older systems may be used with the newer systems, thus reducing the total price tag for upgrade.
 - Non-AT&T vendors targeting these customers with older AT&T systems in place cannot offer the same cost incentives to migrate from the AT&T systems to their own products.
 - Consequently, these vendors are at a price disadvantage versus AT&T.
- In addition to the trade-up incentives associated with purchase that ATT-IS is able to offer, ATT-IS is also offering rental policies that provide incentives for those customers wishing to continue to rent equipment rather than purchase.

- ATT-IS also has the ability to bundle equipment and service pricing in such a manner as to provide attractive alternatives to non-AT&T products which do not have bundled equipment and service.
 - In addition, the classic dilemma of interfacing equipment among multiple vendors exists with non-AT&T PBXs where ATT-IS is able to minimize the interface problems between their own PBX and communications facilities and services provided by AT&T Communications (ATT-C) and other common carriers.
- Through strategies such as long-term rental agreements, bundled system pricing techniques and incentives for upgrading of older equipment, AT&T is endeavoring to lock up a large percentage of its existing customer base and thereby continue to increase market dominance in the PBX field.
 - In particular, the early adherence of American Bell (now ATT-IS) to rent-only pricing is a clear indication of AT&T's strategy to pursue its migration marketing philosophy even after deregulation.
 - Under the long-term rental environment, AT&T's customers remain considerably more captive to retaining AT&T PBX equipment based on financial commitments that cannot be easily cancelled without substantial financial penalty.
- Another apparent AT&T strategy relating to customer premises equipment involves the discontinuance of certain equipment subsequent to divestiture, the absence of which tends to force customers to upgrade to newer equipment.
 - Even if AT&T does continue to provide certain products indefinitely, as it has assured the FCC that it will, future enhancements and adequate supply of products may not be readily provided and, if this is the case,

migration to new and more sophisticated products will be forced upon the ATT-IS customers (although not necessarily from ATT-IS).

C. CENTREX VERSUS ON-PREMISES PBXs

- In addition to the trend toward rapid replacement of older generation PBXs, there is also a major movement among users to convert from Centrex systems (where the telephone company provides the switch in its central office) to on-premises PBX systems.
 - Roughly 50% of Centrex users have indicated a desire to convert as soon as possible from Centrex to on-premises PBX systems.
 - Of the remaining 50% who indicate that they will stay with Centrex, about half say that they will convert to an on-premises PBX within two years.
 - Such control is not possible with Centrex. In addition, regardless of the new feature that might be incorporated into Centrex, the general feeling is that on-premises PBX systems can provide considerably more flexibility and capability than would ever be possible via Centrex.
 - Furthermore, the third- and fourth-generation PBXs with their strong links into other areas of office automation provide a level of sophistication that Centrex could never completely duplicate.
 - In addition, the integration of third- and fourth-generation PBXs into an LAN-based system demands an on-premises product, if only from a standpoint of physical integration with the rest of the system.

D. "BYPASS"

- Because of the continued hold that the RBOCs will have on many services related to on-premises PBXs, customers will be looking to the greatest extent possible to limit their dependence on "bottleneck" services such as control trunk facilities offered by the RBOCs.
 - This will involve the development of alternative "bypass" services that will allow customers to access the outside world (packet networks, AT&T, and other long-distance networks) without relying on the RBOCs.
 - In spite of these efforts to bypass the RBOCs' local interconnect facilities, it should be recognized that such services will remain a major element in telecommunications systems for several years to come.
- Consequently, customers will be required to weigh heavily not only the costs of on-premises PBX systems but also the costs of related interconnecting facilities, since rates for these facilities will be based not strictly on cost-related issues but also on strategic factors associated with the profitability and competitiveness of the RBOCs.

E. EXPECTED SUPPLIER SHAKEOUT

- The growth in PBX shipments in future years will be rather modest when the total market is considered. Specific segments, however, (the low-end and the high-end) will continue with rather solid growth.
- Because of the still-existing older generation PBXs that have not yet been replaced as a result of AT&T's migration strategy, and because of the roughly

15,000 existing Centrex systems, which are candidates for replacement, PBX sales for 1984 and 1985 should continue their recent momentum.

- Beginning in 1985, however, fewer installed older generation PBXs will be available for replacement and the overall market growth could decline somewhat.
- Further dampening of the PBX shipments could occur if the new RBOCs make Centrex more attractive by reducing and/or stabilizing rates and adding features that are reasonably competitive with on-premises PBXs.
- PBX shipments are also related to real business establishment growth, facility relocations, and new installations associated with expanded technological requirements such as sophisticated office automation systems.
 - Nevertheless, the major element in PBX market growth is replacement of older systems and, as noted above, this replacement market potential is estimated to be shrinking. The replacement market is also negatively affected by AT&T's hold on many users who have PBXs under two-tier pricing and Variable-Term Payment Plan (VTTP) contracts.
 - Well-performing second-generation PBXs currently installed, such as Bell Dimension, Mitel's SX-100 and ROLM's CBX, will be difficult to replace based on cost analysis and feature requirements criteria.
- The slowing of overall market growth, coupled with the large number of vendors now offering PBX products, indicated that a shakeout of PBX suppliers is inevitable over the next few years.
 - Many emerging voice/data PBX vendors, such as CXC, Ztel, and D.A.V.I.D. Systems, are entering the high-end market segment.

- Entry into the high-end segment is risky because of the extensive software development required and difficulties associated with establishing effective distribution and support channels with interconnect companies, RBOCs, and Independent Telephone Companies.
- In addition, high-end entrants will be faced with intense competition from well-established suppliers, such as AT&T, Northern Telecom, ROLM, and InteCom.
- Major high-technology manufacturers, such as Rockwell International and Datapoint, have been successful in establishing themselves in the high-end voice/data PBX segment.

F. MERGING OF PBX AND COMPUTER COMPANIES

- A major trend in the PBX product area is the merging and/or joint venturing of computer and PBX companies and products.
 - The most notable of these relationships is IBM's acquisition of ROLM.
 - This will allow IBM to compete directly with AT&T for data communications transmission business.
 - Originally, IBM had signed an agreement with Mitel for a joint venture to develop a new family of IBM switching systems that would take advantage of Mitel's PBX capabilities and IBM's information-processing expertise.
 - Because of delays in Mitel's SX-2000 PBX product development, IBM changed course and embarked on its endeavor with ROLM.

- Another example of this trend is Northern Telecom's courting of computer manufacturers as part of its Open World philosophy.
 - Northern Telecom has made available to other data processing and office equipment suppliers some of the key specifications for the SL-1/SL-100 PBX equipment.
 - In addition, Northern Telecom has signed agreements with Data General, DEC, Sperry Univac, and HP that provide for the interfacing of the SL-1/SL-100 PBXs to these various computer systems.

G. VOICE/DATA WORKSTATIONS

- Office automation system designers are increasingly focusing on reaching the managers and executives with advanced workstations that perform a variety of functions, including both voice and data.
 - Senior management personnel will more and more be using enhanced telephone terminals that combine many of the features of personal computers and telephone instruments.
 - These terminals, in order to be readily adapted, will need to be easy to use without requiring learning of special functions and will also be closely tied to the well-known telephone system operation.
 - This integrated voice/data terminal or workstation will be used for accessing information quickly and easily through the PBX system.
 - Terminals that currently satisfy these requirements are ROLM's Cypress Personal Communications Terminal and executive workstations

such as Mitel's Kontakt, GTE's ActionStation, and Northern Telecom's SL-I Displayphone.

- As the costs of technology are falling substantially, administrative personnel costs are rising. Consequently, the cost-effectiveness of the new sophisticated workstations and the power that these can bring in terms of producing work are becoming increasingly cost-justifiable when weighed against the personnel cost of performing functions in a less automated way.

H. PRICES AND COSTS

- The issue of "cost per line" or "price per line" for today's PBX systems is elusive in that there is a difficulty in insuring that a truly "apples and apples" comparison is being made.
 - Fully installed end-user prices per line range from a low of around \$500 to a high of over \$2,000.
 - In order to directly compare costs and prices, an identical system configuration is needed as a benchmark against which all suppliers can provide data.
 - This function of creating an identical system specification typically falls on the user in the process of creating an RFP document.
 - A distinction needs to be made between a PBX's price per line and a PBX's cost per line.
 - Even though the price per line is often higher as a result of added functionality, the actual cost for providing this capability is not necessarily significantly greater.

- In those competitive situations where it is in a company's strategic best interest to cut prices, some have plenty of room to maneuver with regard to margins and have been willing to do so.
 - Other suppliers with tighter margins have been forced to cut prices in order to be competitive and have been hurt in the process.
- In the case of PBXs sold to Telcos, there are many games being played among competitors regarding system pricing.
 - This situation exists as a result of many ancillary support items that need to be added to the basic price of the system in order to come up with a total price.
 - For example, training and documentation expenses need to be considered when looking at total system price to Telcos since these items can be very expensive.

I. THE MULTITENANT PBX BUSINESS

- The FCC's recent deregulation of the telephone industry has created a major new PBX market in shared multi-tenant communications services. The market for these services could exceed \$1 billion over the next three years.
- Multitenant communications services provide integrated voice and data communications to the tenants of office buildings, industrial parks, and other real estate developments. In addition, college campuses and other facilities consisting of diverse groups of individuals are well suited to multitenant voice/data PBX applications.

- Many of the individual tenants, because they are small, cannot afford the advantages of a sophisticated PBX system offering a wide variety of voice, data, and office services. With multitenant systems, even the smallest tenant has access to powerful application capabilities, such as call detail recording, least-cost routing, voice and data networking, electronic mail, facsimile, word processing, video conferencing, and other systems and services that enhanced productivity.
- PBX suppliers such as InteCom and ROLM have been successful in installing their new PBX systems in multitenant environments.
 - The PBXs offered by these companies are capable of handling both digital voice and high-speed data efficiently and have system architectures allowing partitioning of individual customers, each having full access to the total PBX system capability.
 - Many multitenant projects have been planned throughout the country; several have been begun and a number have been completed. In spite of the fact that multitenant projects involving PBXs are now operational, this new segment of the PBX industry is still in its infancy.
 - Because of the successes of initial installations, however, the revenue potential from multitenant installations is very substantial and PBX suppliers are focusing on this new business segment as a major source of future business.
- Many new independent companies, such as Tel-Management Corp. in Dallas and Electronic Office Centers of America in Chicago, have recently come into existence to provide multitenant PBX systems to developers.
 - One of the first multitenant projects in the country was the office tower of the Galleria shopping mall in North Dallas.

- This early multitenant installation was handled by Tel-Management using an InteCom IBX system. The IBX switch was ideally suited for the multitenant application because of its ability to allow partitioning of the system.
- Tel-Management provides all of the station equipment, including the most sophisticated electronic telephones offered by InteCom.

- Another multitenant project undertaken by Tel-Management is the United Bank Plaza in Houston.
 - Virtually all of the tenants in the United Bank Plaza have signed up for the Tel-Management services.
 - This tenant acceptance of sophisticated voice/data PBX services indicates that such services have been an inducement for these tenants to occupy the facility.
 - As a result of this exceptional degree of attractiveness, it is expected that the multitenant services business will become a standard part of all the progressive new office developments, thereby providing a strong impetus to voice/data PBX market growth.
- The United Bank Plaza project utilizes a ROLM system, configured by Tel-Management specifically for the multitenant application.
 - The ROLM system, like InteCom's, can be partitioned into approximately 1,000 separate compartments, allowing individual tenants to have full access to the system capability, while not interfering with each others' operation.
 - The ROLM system will be equipped with Cypress personal communications terminals and a variety of ROLM phone devices.

- In addition to the emerging, entrepreneurial types of businesses, such as Tel-Management Corporation, and the in-house services provided by developers such as Lincoln property, large communications companies are also establishing internal organizations to address the multitenant PBX market.
 - Satellite Business Systems (SBS), for example, has established a subsidiary called SBS Real Estate Communications Corporation (RealCOM).
 - RealCOM will specialize in providing hardware/software and systems management covering the full range of communications services required by real estate developers.

J. PROBLEMS IN IMPLEMENTATION

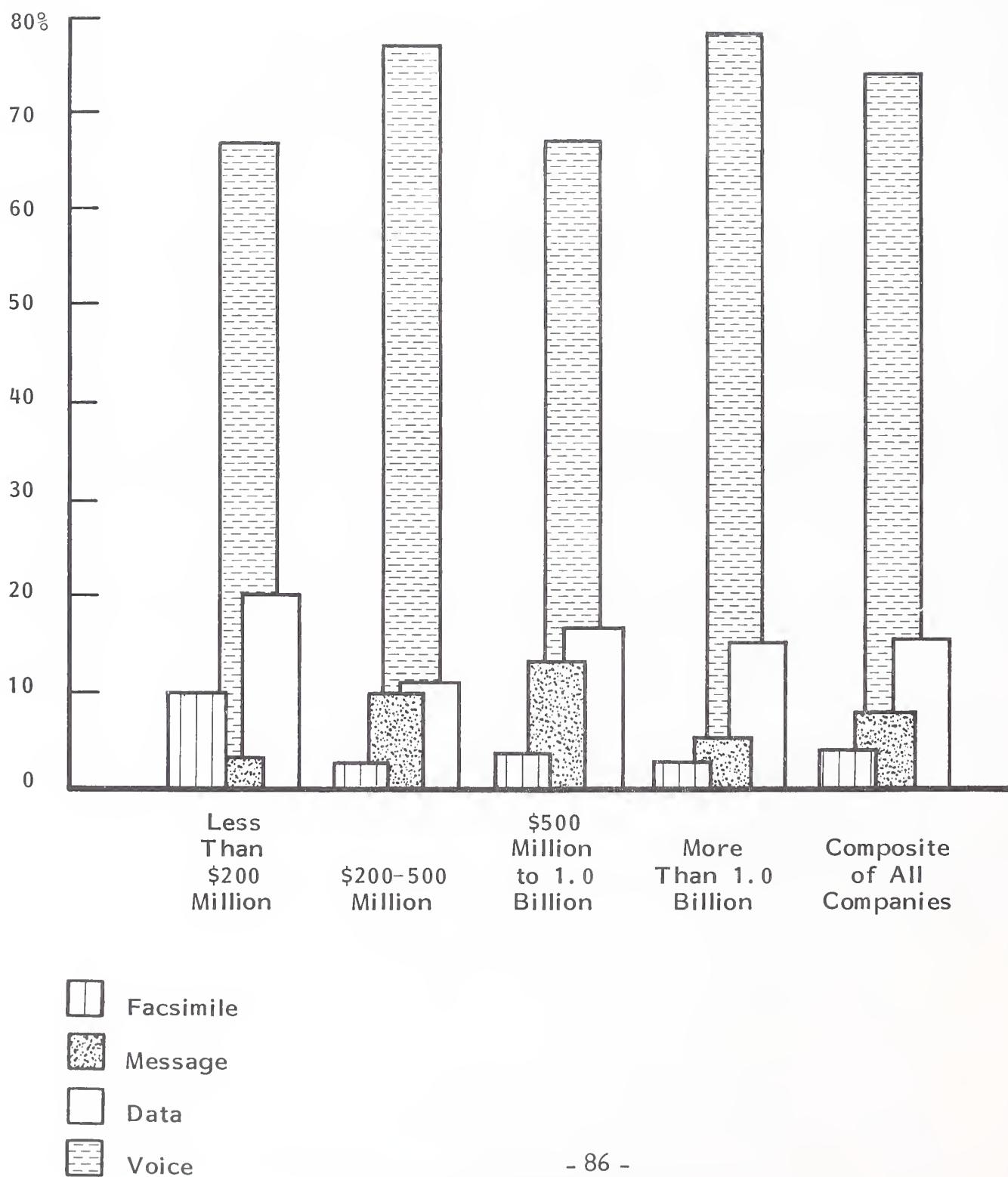
- As is the case with many of the new electronic products, the user community cannot keep pace with the advances in technology in terms of being able to incorporate the new products into their application environments in a timely fashion.
 - The implementation of technology usually lags by at least a few years the availability of this technology.
 - This lagging in the implementation of new PBX product/technology will probably have a somewhat negative impact on the growth rate of the third- and particularly the fourth-generation PBX suppliers.
 - This lag effect will benefit companies with existing installed bases of older PBX equipment, such as AT&T, ROLM, and Northern Telecom.

- These companies have, in many cases, captive customers since the costs and operational trauma associated with changing a major in-place PBX installation often is not offset by the supported benefits of a newer product.
- The features and functions available in the newer products need to be integrated into an overall office automation system.
- This integration process involves other systems, such as LANs, and computer-based applications being designed and implemented in concert with the new PBX, in order for the total capability to be realized.
- This process of design and systems integration is an extremely difficult one and many companies, even the largest and most sophisticated, have been hard pressed to develop a comprehensive, integrated system design and to follow through with implementation and operation.

- Many of the largest corporations still have not addressed the internal organizational issues of consolidating various communications, data processing, and office systems functions into a single organization.
 - The fragmented organizational structures that exist in many large companies are not conducive to the design and implementation of sophisticated, integrated office automation systems.
 - Exhibit IV-1, for example, shows how the telecommunications budgets within various-size companies (grouped by revenues) are allocated by functional areas.

EXHIBIT IV-1

USE OF TELECOMMUNICATIONS SERVICES BY SIZE OF COMPANY



K. CONCLUSIONS

- Close OEM/joint development associations between PBX suppliers and computer manufacturers are becoming common. These types of relationships offer the computer manufacturers access to voice users and applications, and the PBX suppliers a tighter link into the information processing world as well as an excellent channel of distribution.
- Increased price competition has placed vendors under tight profit margin pressure. This pressure is expected by some to lessen somewhat, but competition and technological advancements would seem to dictate at least a five-percent-per-year price erosion.
- Noncommunications cost savings and/or productivity gains will justify future communications expenditures. This will become an important consideration when a company develops its telecommunications strategy.

L. EXHIBITS

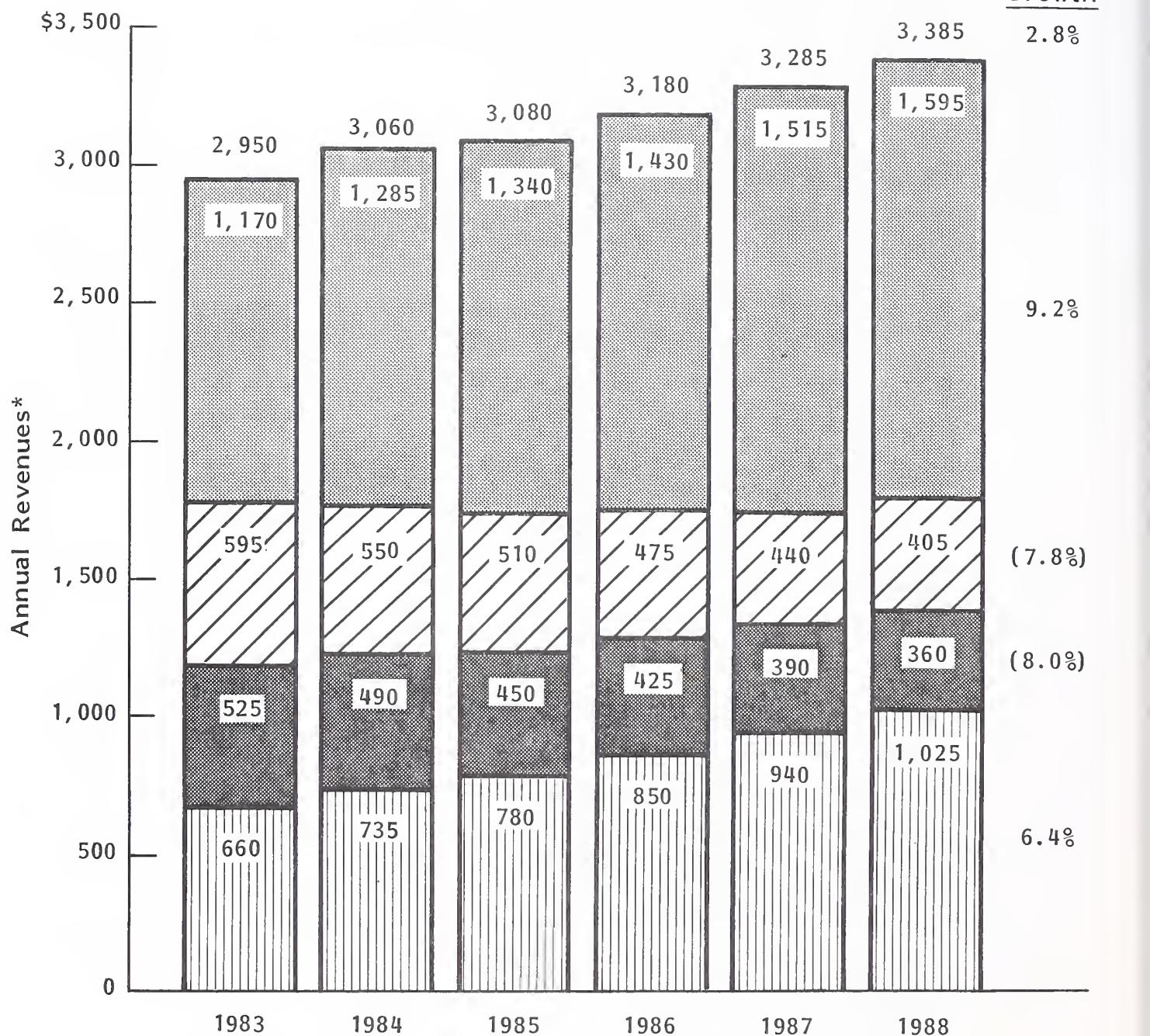
- Exhibit IV-2 summarizes in graph form the anticipated PBX revenues for the period 1983-1988. The year 1983 is the baseline of real numbers. The growth rate, in percentages and in number of units, is clearly evident. However, it is important to be aware of where this grow is occurring--that is, which size of PBX has the greatest growth in any given year.
- Exhibit IV-3 shows how the percentage of estimated total lines shipped varies between 1983 and 1988.
 - The "500 lines and above" PBX category is seen to increase from 38% of total lines shipped in 1983 to 45% of total lines shipped in 1988.

EXHIBIT IV-2

U.S. PBX REVENUES

1983-1988

Percent Average Annual Growth



PBX Sizes:

- 500 Lines & Above
- 100-249 Lines
- 250-499 Lines
- Under 100 Lines

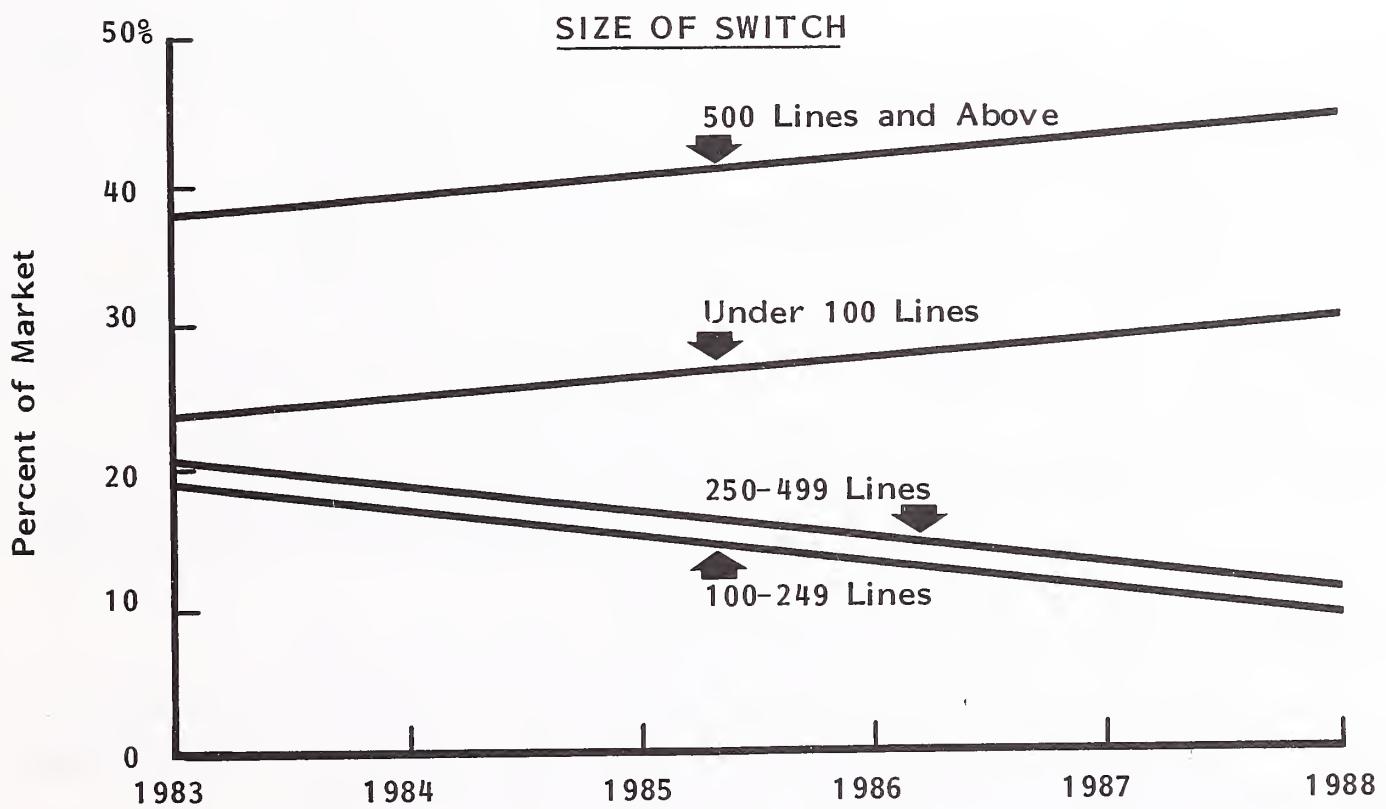
* Revenues Exclude: Centrex, Key Systems, and "Feature Phones"; Voice/Data Workstations/Terminals; Ancillary Applications; Enhanced Software

EXHIBIT IV-3

U.S. PBX MARKET SHARE TRENDS BY SIZE OF SWITCH

1983-1988

(Based on Number of Lines Shipped)



- The "under 100 lines" category is seen to be increasing from 24% in 1983 to 32% in 1988.
- The other two categories, spanning switch sizes from 100 to 499 lines, are seen to be decreasing from around 20% in 1983 to a level of around 10% in 1988.
- The exhibit points out the attractiveness of the high and low ends of the PBX spectrum.
- Even though the overall market segment between 100 and 499 lines is decreasing, the opportunities for emerging, state-of-the-art, voice/data PBXs in the segment are still significant.
- The two primary reasons for users' interest in converting from Centrex to on-premises PBXs are:
 - Increasing Centrex costs and;
 - Limited features available with Centrex when compared to PBXs.
- If the Centrex replacement trend noted above takes place, approximately 11,000 Centrex systems will be replaced with on-premises PBXs between now and the end of 1986.

● In spite of the strong interest among users to convert from Centrex to on-premises PBXs, Centrex service will continue to be offered for the short term by the RBOCs.

- This is because many RBOCs have large investments in Centrex capacity, including central office switching and local facilities con-

necting the central office switching equipment to the customer premises.

- Because of this large investment in plant and equipment relating to Centrex Service, the RBOCs will presumably aggressively offer Centrex as a cost-effective alternative to on-premises PBX systems, at least for a few years.
- RBOCs will be motivated to reduce the cost of Centrex services and/or limit future rate increases associated with Centrex.
 - Also, the RBOCs will, in the short run, most likely leverage other services associated with on-premises PBXs so that the cost-effectiveness of on-premises PBX installations may be lessened as compared to the alternative of using Centrex.
 - For example, costs of such services as Direct Inward Dialing (DID), associated as a special offering with PBXs but provided as standard service with Centrex, would be increased so that PBX service, with the added cost of DID, would be less cost-effective than Centrex.
- Another way in which the RBOCs can continue their support of Centrex versus competitive on-premises PBX equipment is the upward adjustment of off-premises extension (OPX) rates associated with on-premises PBXs, but not associated with Centrex.
 - OPXs are circuit facilities connecting users located in separate buildings to the central PBX.
 - Rates of between \$50-\$100 per OPX line are possible in many locations.

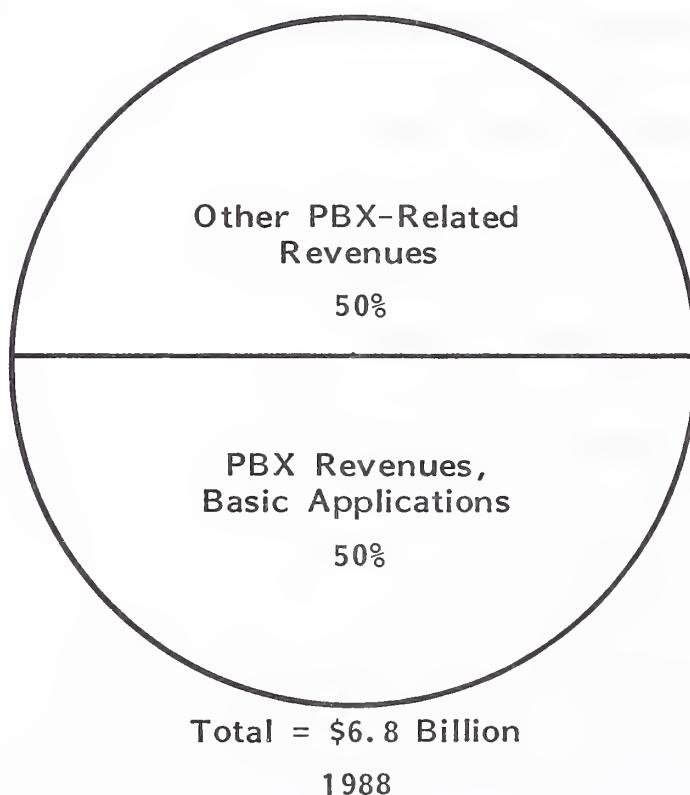
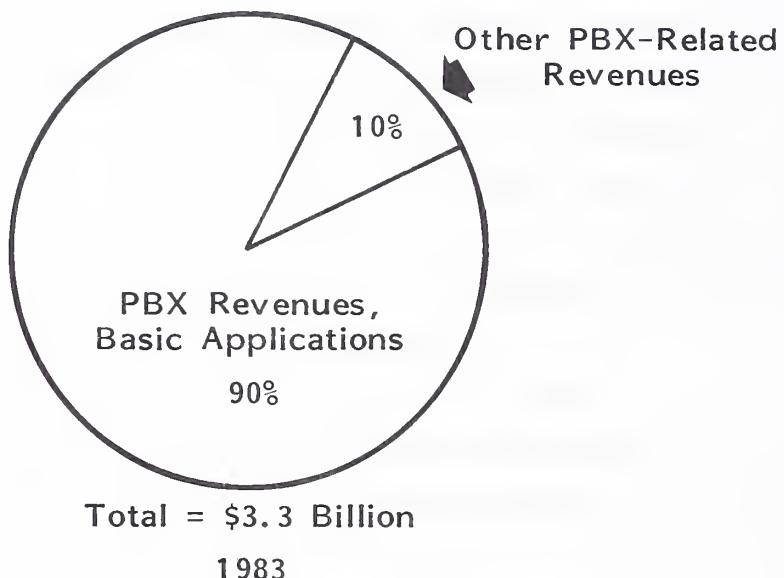
- These high charges for short-distance OPX lines render the overall costs of installing an on-premises PBX in many cases higher than a comparable Centrex solution.
- The RBOCs have the leverage to mitigate against competitive on-premises PBXs through adjustment of associated circuit facility rates.
- These examples of how the RBOCs might leverage their exclusive, regulated services indicates the continuing influence that the RBOCs will be able to exert over their customer base.
- Consequently, the theory of increased competition associated with the breakup of AT&T and other decisions of the FCC and the courts, while correct in theory, will, in practice, be faced with major barriers resulting from the RBOCs' control over regulated services, which are, and will remain in the foreseeable future, noncompetitive.

- The key to the RBOCs' strategies will be the extent to which their own competitive on-premises PBX products will generate more revenues and profits than an alternative Centrex offering.
 - This equation has not yet been clearly defined, but the suspicion is that the RBOCs will eventually gravitate toward their own competitive on-premises PBXs and that Centrex will gradually be dropped as a primary service offering.
 - This strategic move will, in large part, be forced by what appears to be a customer preference for on-premises PBX systems versus Centrex.
 - The primary reason expressed by customers for this preference is the ability to achieve "hands-on" control over their own system.

- This huge market is an understandable enticement for the present PBX manufacturers and the many emerging PBX companies.
- In determining market share for various PBX suppliers, one should not only use end-user price per line when determining split among various PBX companies. The actual number of lines shipped for a given amount of revenue are dependent, among other factors, upon what portion of total shipments goes to end-users versus what percentage goes to OEMs.
 - The OEM price per line is often almost half of the end-user price per line. Consequently, for a given amount of revenue, a manufacturer selling exclusively to the OEM market would actually ship roughly twice as many lines for the same amount of revenue as a supplier exclusively selling in the end-user market.
 - The split between voice-only lines and voice/data lines also needs to be considered. A voice line might be priced at \$800 and a voice/data line at \$1,300. Thus, a supplier providing systems with all voice lines would deliver 63% more lines than a supplier providing all voice/data lines.
- Exhibit IV-4 presents an approximation of the extent to which revenues over and above those associated with basic PBX applications will be expected to grow between 1983 and 1988.
 - Currently, only about 10% of the total PBX-related revenues, exclusive of key systems, relates to nonbasic PBX applications. By 1988, this figure should be at least 50%.
 - Such items as "feature phones," voice/data workstations and terminals, electronic mail, voice messaging and enhanced software features and capabilities relating to a variety of office automation and networking applications are projected to eventually provide PBX suppliers with as much revenue as their basic PBX products--perhaps even more.

EXHIBIT IV-4

COMPARISON OF PBX REVENUES (BASIC APPLICATIONS)
VERSUS OTHER PBX-RELATED REVENUES*



* Other PBX-Related Revenues Included; Feature Phones, Voice/Data Workstations/Terminals, Ancillary Applications, and Enhanced Software (Key Systems not Included)

- Many feel that the basic PBX will simply represent a "foot in the door" sale and that the real revenue potential will be generated from the additional capabilities which can be added on to the basic PBX once the customer has committed to a given system. These add-on features and equipment should also typically carry good margins.
- In looking at the combined revenues of basic PBX systems and other PBX-related features and equipment, revenues may increase from \$3.3 billion in 1983 to \$6.8 billion in 1988.

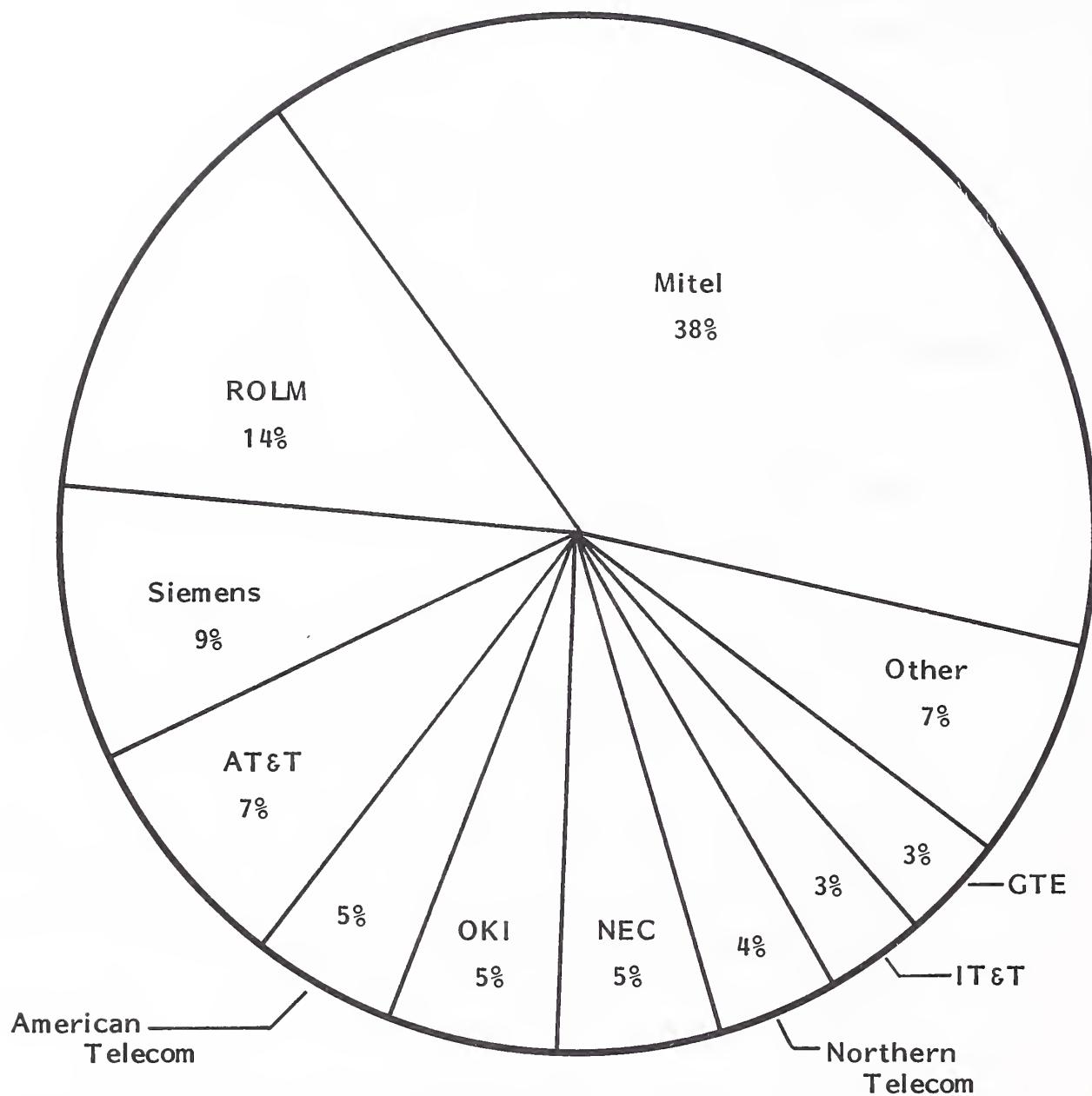
● As can be seen in Exhibits IV-5, IV-6, and IV-7, suppliers' market shares in individual line-size categories vary significantly.

- For example, Mitel is estimated to have 38% of the market in the "under 100 lines" category, but an indistinguishable share of the market in the "500 lines and above" category.
- Similarly, AT&T is seen to have 30% of the market in the "100-499 lines" category and 25% of the market in the "500 lines and above" category, but only 7% of the market in the "under 100 lines" category.
- Do not expect a great amount of shifting in the line size product emphasis of major suppliers over the next few years. However, there are exceptions, such as Mitel's movements into the "500 lines and above" segment with their SX-2000 digital PBX and InteCom's move into the "100-499 lines" category with the IBX S/10.
- In spite of some difficulties getting the SX-2000 product off the ground, Mitel will be successful in obtaining a significant market share of the high-end business (perhaps as much as 3-5% by 1986).

EXHIBIT IV-5

1983 U.S. PBX MARKET SHARES BY MANUFACTURER
(Based on Number of Lines Shipped)

FOR SYSTEMS UNDER 100 LINES



.8 Million Lines Shipped

EXHIBIT IV-6

1983 U.S. PBX MARKET SHARES BY MANUFACTURER
(Based on Number of Lines Shipped)

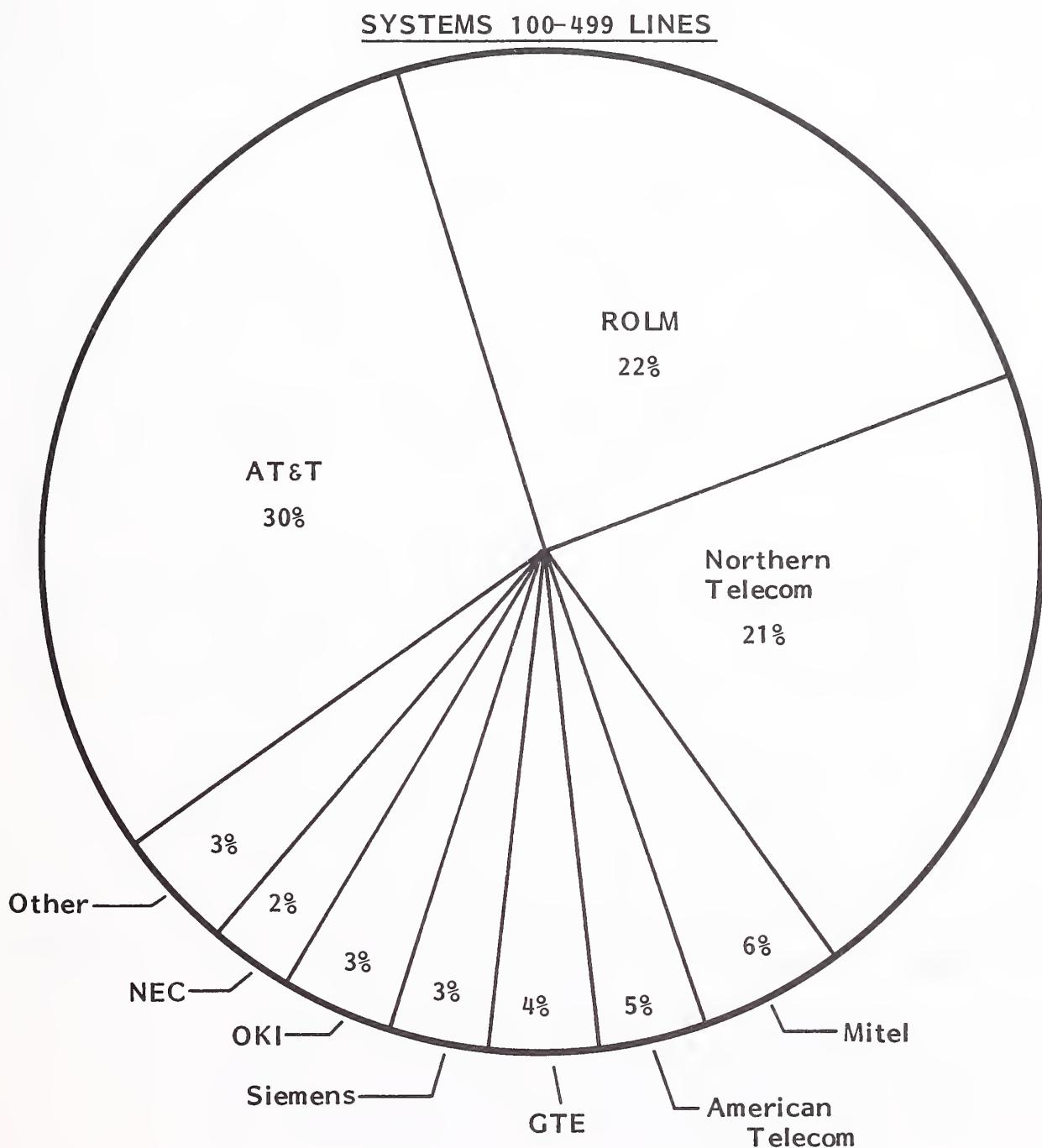
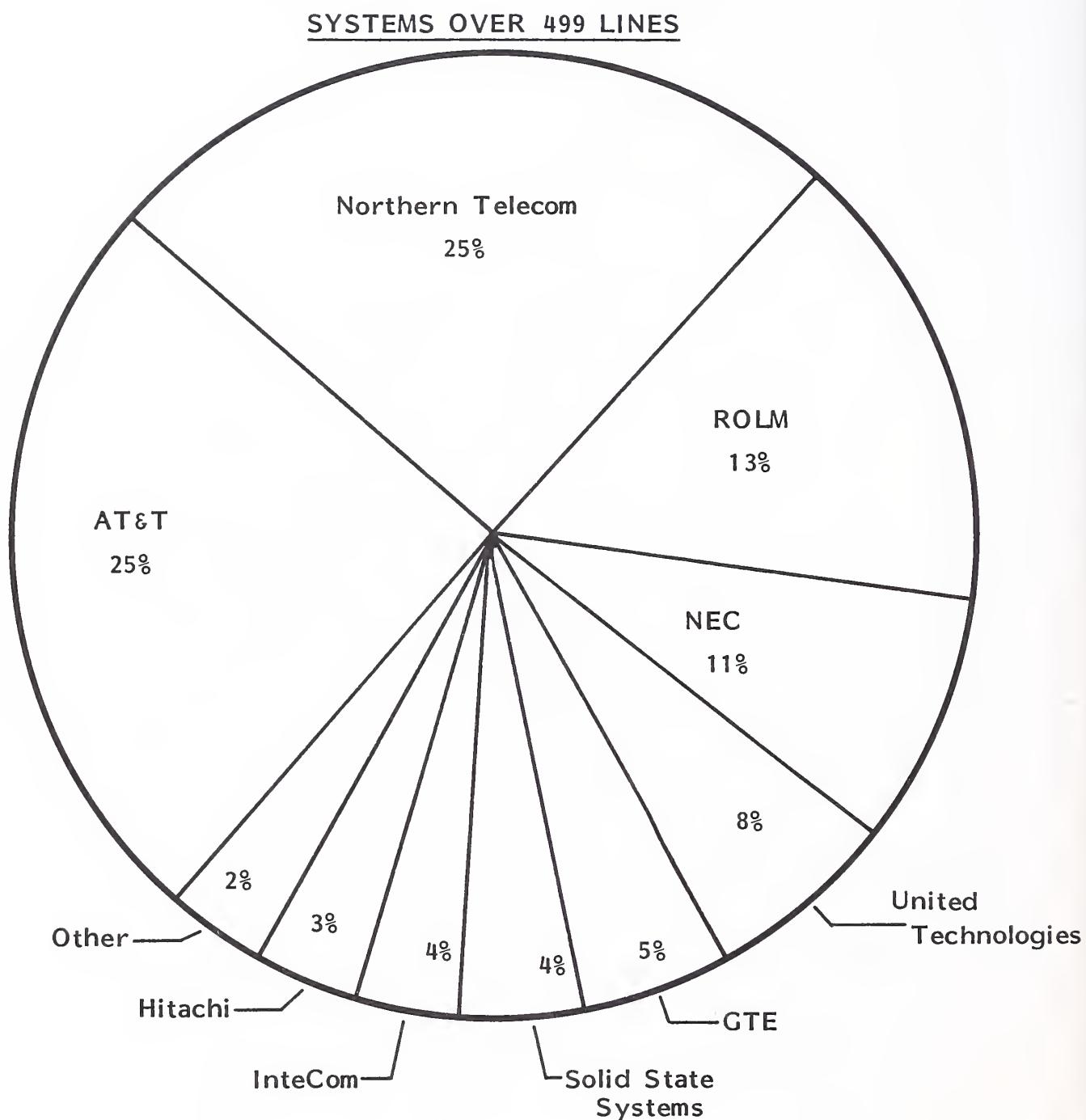


EXHIBIT IV-7

1983 U.S. PBX MARKET SHARES BY MANUFACTURER
(Based on Number of Lines Shipped)



- InteCom's S/10 was not available until mid-1984 but should also eventually be successful in capturing some low- and medium-end market share for InteCom.
- Exhibits IV-8, IV-9, and IV-10 represent estimated PBX market shares by major channels of distribution.
- Exhibit IV-8 reflects the market share of ATT/RBOCs only.
 - In 1983, it is estimated that AT&T manufactured 95% of PBXs distributed through ATT-IS and the RBOCs.
 - This should change significantly between now and 1988 when AT&T is projected to manufacture only 70% of the PBXs distributed by ATT-IS and the RBOCs.
 - This significant increase in non-AT&T manufacturers selling products via the ATT-IS/RBOC distribution channels highlights the tremendous business opportunities for suppliers such as Northern Telecom, InteCom, and the emerging PBX manufacturers such as CXC and Ztel.
- Exhibit IV-9 reflects the market shares of manufacturers in the Independent Telephone Company segment.
 - Mitel, Northern Telecom, GTE, Harris and ROLM are currently the leading suppliers and should remain so over the next several years.
 - Among the independents, Mitel and Northern Telecom will increase their market share between 1983 and 1988. GTE, ROLM, and Harris will lose small percentages of market share.
- Exhibit IV-10 presents market shares in the interconnect segment.

EXHIBIT IV-8

PBX MARKET SHARES BY MAJOR CHANNELS OF DISTRIBUTION
(Based on Number of Lines Shipped)

ATT-I.S./RBOCS

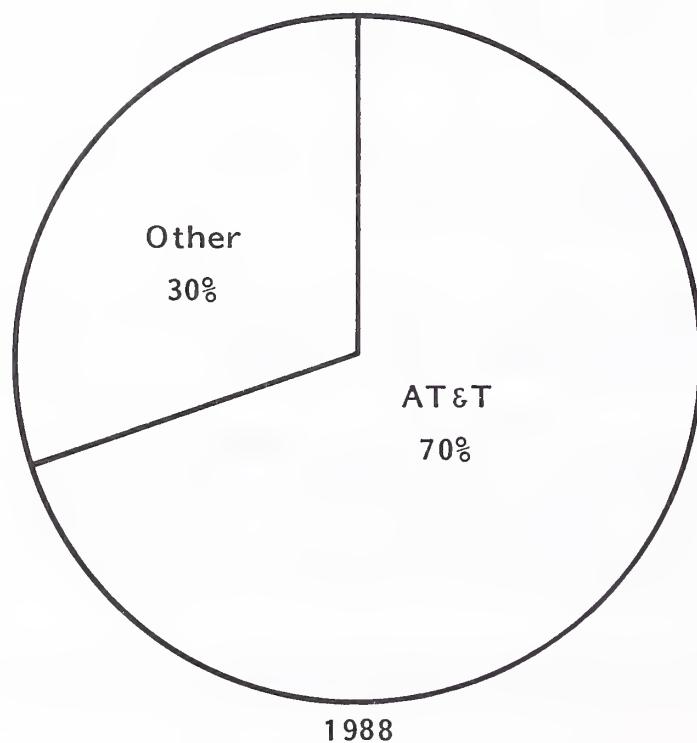
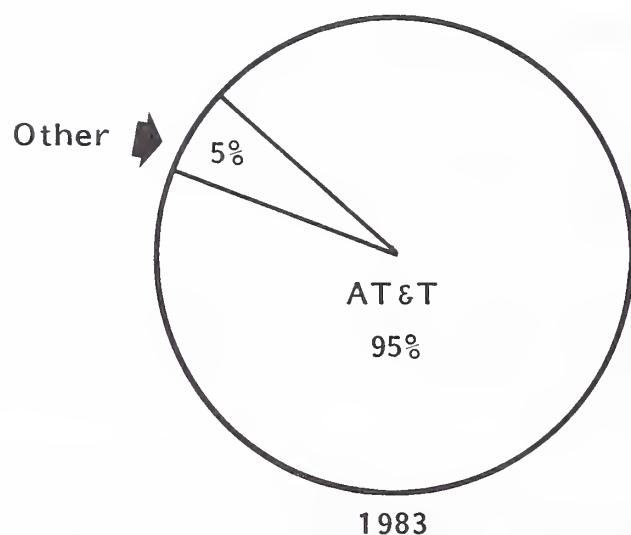
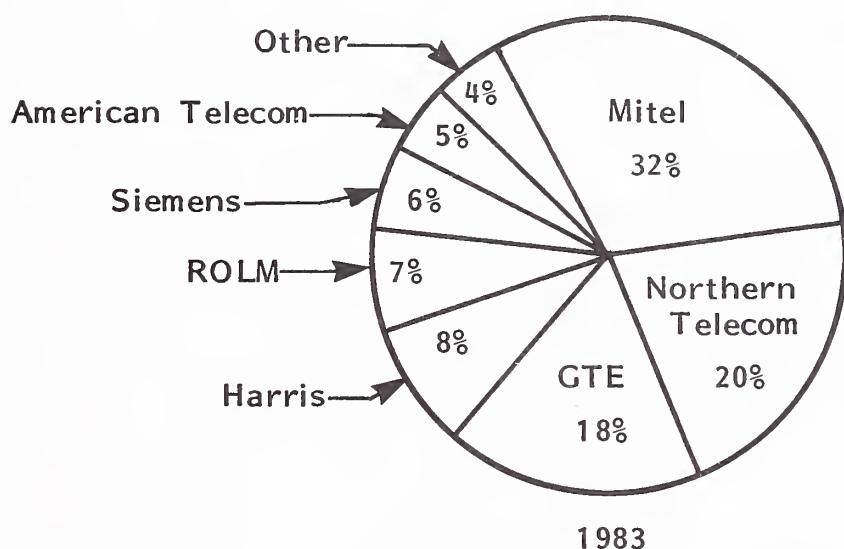


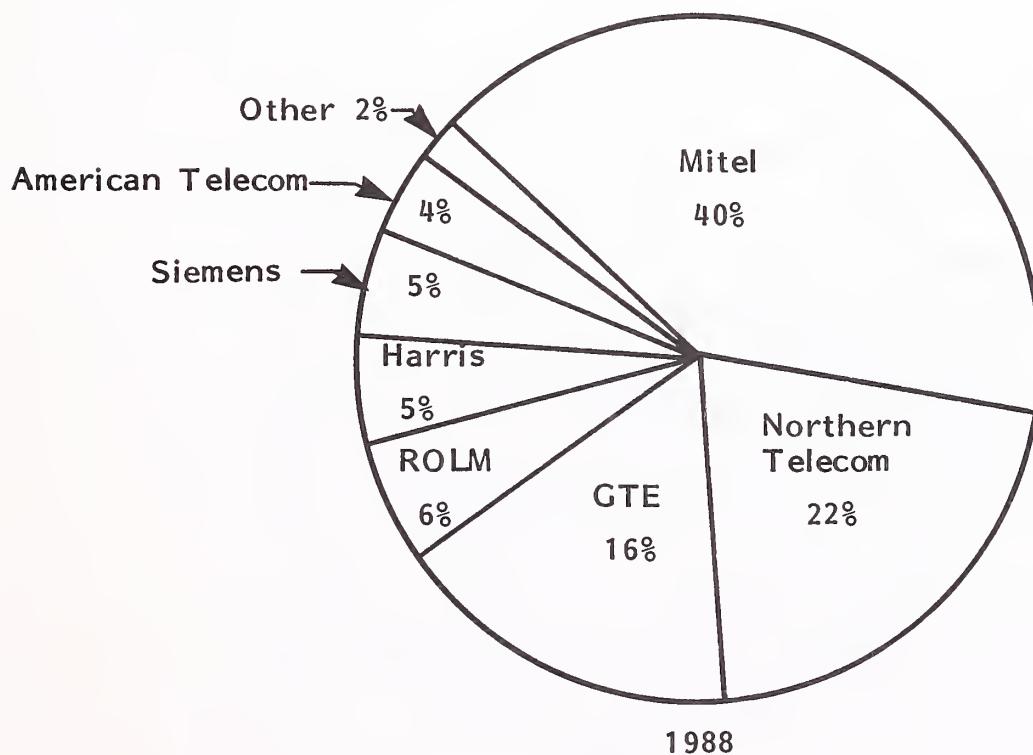
EXHIBIT IV-9

U.S. PBX MARKET SHARES BY MAJOR CHANNELS OF DISTRIBUTION
(Based on Number of Lines Shipped)

INDEPENDENT TELCOS



1983

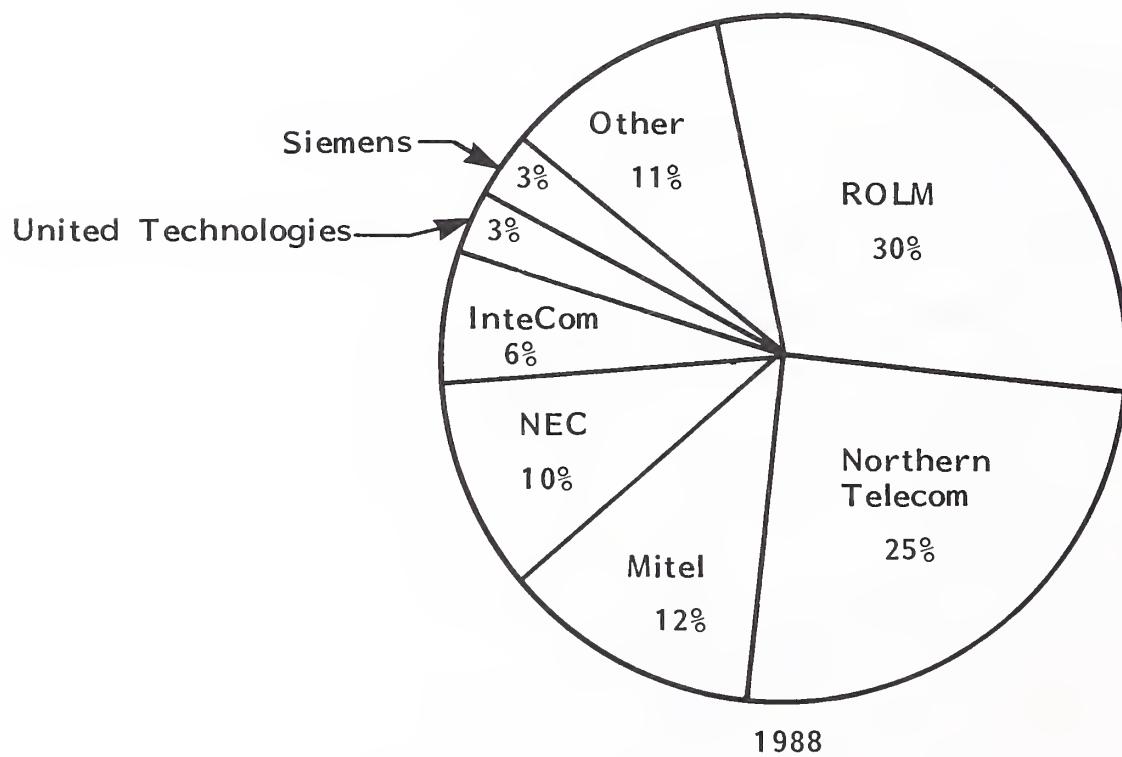
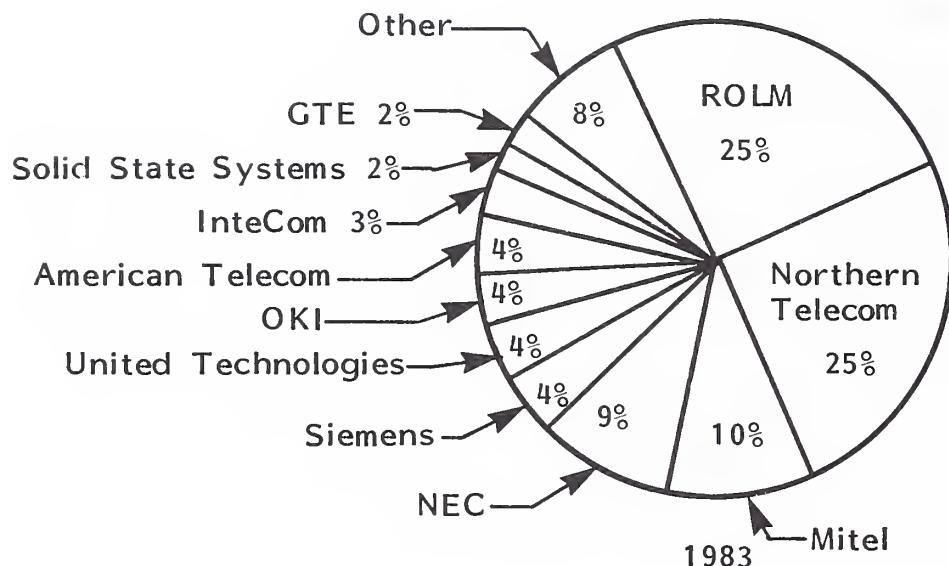


1988

EXHIBIT IV-10

U.S. PBX MARKET SHARES BY MAJOR CHANNELS OF DISTRIBUTION
(Based on Number of Lines Shipped)

INTERCONNECTS



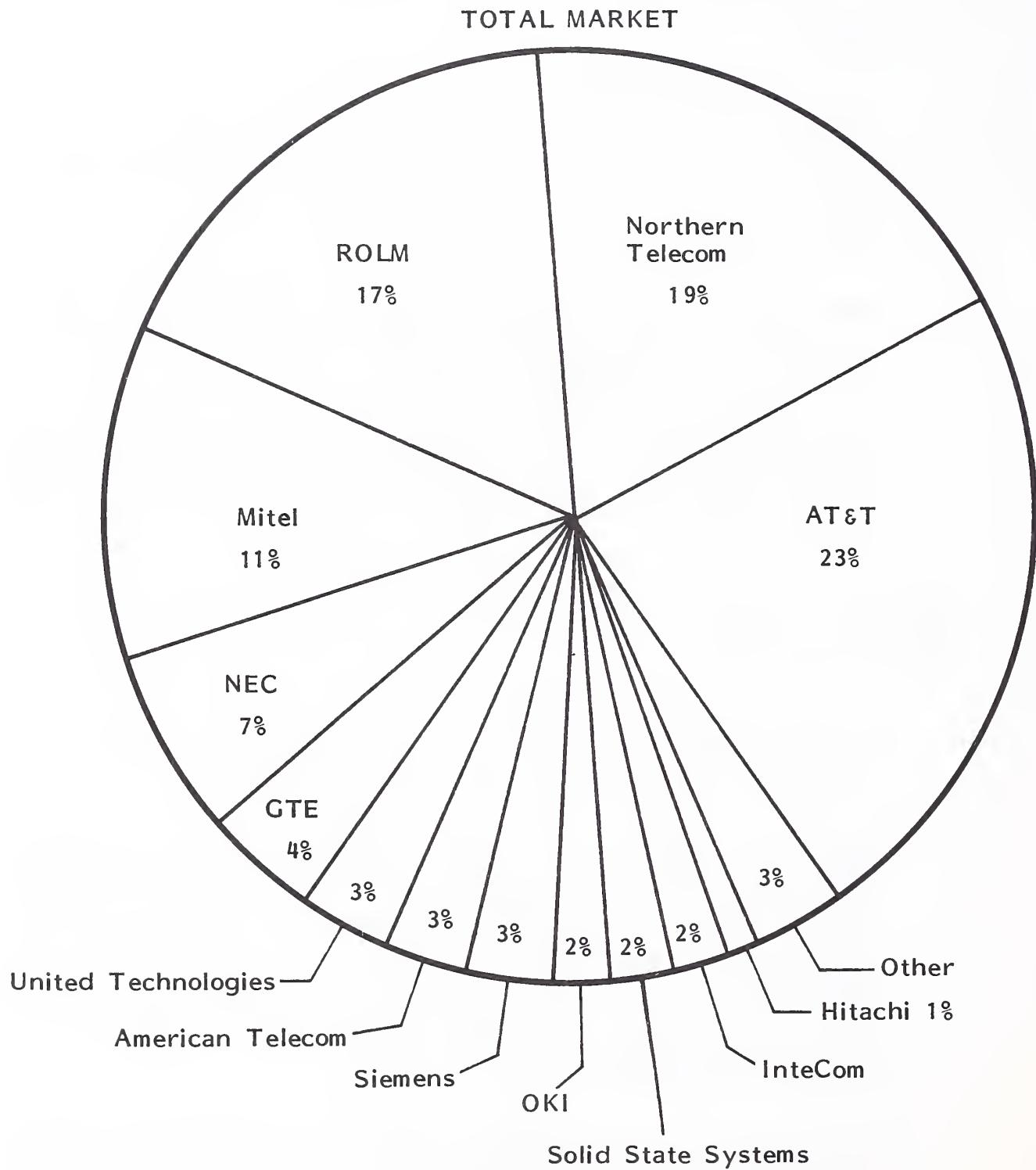
- ROLM is expected to increase its market share from 25% of the interconnect business in 1983 to 30% in 1988.
- Northern Telecom will retain its 25% market share in the interconnect segment.
- Northern Telecom will not be increasing its market share in the interconnect area since it will probably divert products through noninterconnect channels of distribution involving ATT-IS/RBOCs and independent telephone companies.
- Mitel and NEC should increase their market share in the interconnect segment slightly between 1983 and 1988.
- InteCom is projected to make major inroads in market share between 1983 and 1988, growing to an estimated 6% of the total market at the end of this period.

● Exhibit IV-11 presents estimated market share breakdowns by manufacturer, based on total market.

- As regards market shares for the total market, AT&T, Northern Telecom, ROLM, Mitel, and NEC are seen to dominate.
- These five manufacturers represent an estimated 77% of the total market based on number of lines shipped. AT&T, Northern Telecom, and ROLM alone make up an estimated 59% of the total PBX market. This domination of the market by a few manufacturers, however, still leaves ample room for other suppliers since the market itself is huge (3.4 million lines shipped in 1983).
- While the five suppliers mentioned dominate a good percentage of the market, there is much more room today for improved positioning of

EXHIBIT IV-11

1983 U.S. PBX MARKET SHARES BY MANUFACTURER
(Based on Number of Lines Shipped)



market share than a few years ago when AT&T had well over 50% of the total market.

- Even a very small market share, such as InteCom's estimated 2%, provides sufficient opportunity to develop substantial revenues and profits.
- Exhibits IV-12 and IV-13 present the estimated breakdowns of U.S. PBX shipments by switch size in terms of percent of total systems (Exhibit IV-12) and percent of total lines (Exhibit IV-13).
 - The most significant aspect of these two figures relates to the fact that 70% of the estimated system shipments in 1983 were in the "under-100-lines" category (Exhibit IV-12), whereas only 24% of the estimated lines shipped (Exhibit IV-13) were in this category.
 - Conversely, the "500 lines and above" category represented only 7% of the total systems shipped but 38% of the total lines shipped.

EXHIBIT IV-12

1983 PBX SHIPMENTS BY SWITCH SIZE
(Based on Number of Systems)

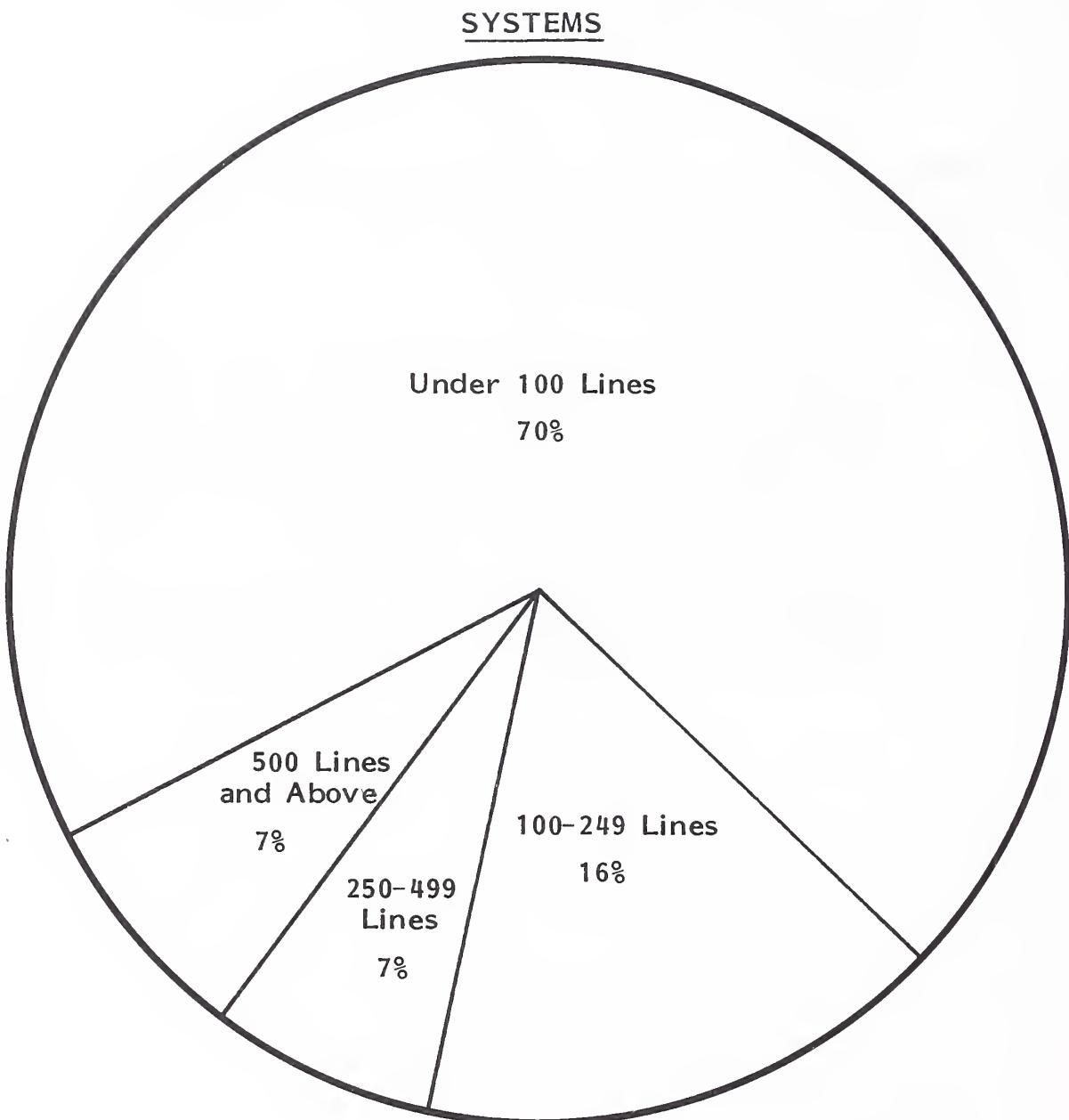
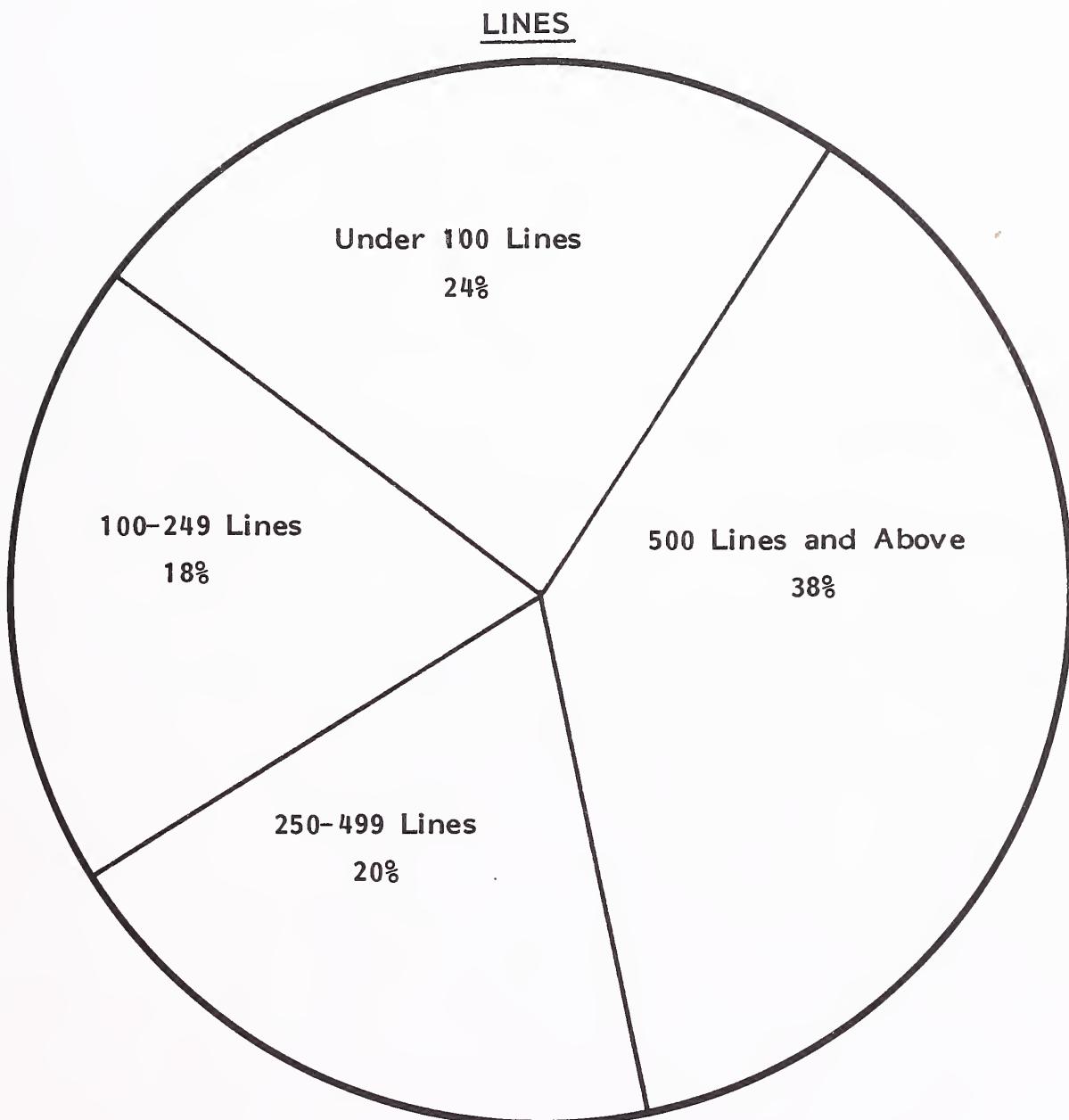


EXHIBIT IV-13

1983 PBX SHIPMENTS BY SWITCH SIZE
(Based on Number of Lines)



V CONCLUSIONS AND RECOMMENDATIONS

V CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

- As a result of the emergence of local area network (LAN) technologies with associated higher transmission speeds, and the need to integrate PBXs with LANs, major PBX design efforts are being focused on, providing for LAN interfaces and greater PBX system throughput.
- Leading PBX suppliers are pursuing migration strategies that protect their large installed bases through hardware and software enhancements to older PBX designs.
 - This strategy also applies to some extent to Centrex (a central office-based PBX-type service provided by the RBOCs) in the short term as the RBOCs attempt to provide enhanced Centrex services and retain their Centrex customer bases.
 - In spite of the attempts by the RBOCs to "beef up" Centrex, 50-75% of Centrex systems will probably be replaced by on-premises PBXs within three to five years.
- So-called "fourth-generation" PBXs are being developed by new companies that hope to take advantage of the latest technologies to gain significant market share from the established PBX suppliers.

- Emergence of sophisticated voice/data workstations, sophisticated software enhancements, and new office automation applications will provide PBX suppliers with sizable incremental revenues beyond those generated by basic PBX products.
- Complexities associated with new network service offerings by non-AT&T suppliers such as MCI and GTE SPRINT, coupled with the support and tariff confusions accompanying AT&T's divestiture of the RBOCs, have created the requirements for extensive traffic engineering, network diagnostic, and administrative/cost reporting systems integral to the PBX.
- A shakeout of PBX suppliers is expected. Companies that survive this shakeout must offer products that:
 - Provide a wide range of voice (and usually data/office automation) features,
 - Are priced competitively,
 - Are well supported, and
 - Are marketed through effective channels of distribution.
- The PBX "generation gap" is rapidly closing (and may already be closed).
 - The distinctions between so-called second-, third-, and fourth-generation PBXs have become so blurred as to become almost meaningless.
 - Functionality, reliability, capacity, modularity, maintainability, and price are the important factors, and these characteristics often transcend PBX generation definitions.

- Vertical and speciality application market niches are becoming more and more attractive and profitable for PBX suppliers. InteCom's success in the multi-tenant market is a good example.
- Several important technological directions are being pursued by the major PBX vendors:
 - Extensive applications systems software for the "true" distribution and integration of voice/data features.
 - Sophisticated network management and control features, including fault isolation, network diagnostics, and on-line reporting.
 - Further extensions of open systems interconnections, including the development and certification of high-speed computer-to-PBX interfaces and high-speed PBX links to microwave and satellite facilities.
- The end users' primary reasons for replacing/upgrading their existing PBX systems will focus on issues of capacity (sufficient system size and "horse-power") and bottom line costs.

B. RECOMMENDATIONS

- Satellite technology will have a major impact on telecommunications strategies throughout the 1980s. However, there are problems:
 - Costs are prohibitive for now.
 - There is limited availability of channels.

- Suppliers have yet to demonstrate solid comprehensive support capability.
- LSI and VSLI electronics will create new and unforeseen products and capabilities.
 - One should anticipate a strong movement toward incorporating many telecommunications functions into very small inexpensive electronics packages, especially as chip technology develops and more companies compete.
 - Much of the standalone equipment of the early 1980s will become integrated into major network components, forcing the standalone market to eventually evaporate.
- It is not at all clear that the "super PBX" will be able to fully integrate voice and data.
 - Separate systems for voice and data may still be the wave of the immediate future.
 - The savings of hardware costs resulting from such integration may not offset the costs of separate voice and data systems.
- LANs will diversify their functions, retarding standardization of interfaces and line protocols. If feasible, this can be prevented by using single-vendor configuration, where the LAN vendor also supplies the terminal equipment and interfaces.
- The trend is for all office equipment to have some form of communications capability.

- It is not clear how these components will be integrated into a functional system.
 - The "Super PBX" is one possible solution.
 - Another is for the LAN to control the system.
 - Plan on vendor "customization" of office systems, based on specific use requirements.
- Anticipate the worldwide nature of communications network capabilities. Although fully integrated networks are feasible, actual implementation may be slow in coming due to the requirement that "in-country" telephone companies must approve all new international communications services.
- Cellular radio may eventually supplant existing telephone systems. For now, the technology does not seem to lend itself to mass market applications, except as a high-priced status symbol. (For that reason, it was not discussed in the body of the report.) Satellite technology could change that overnight. One should be flexible enough in planning to consider these ramifications.
- Plan on continued heavy use of voice, which now is approximately 85% of all transmissions. Voice will continue to be the most significant element in a total telecommunications environment.

APPENDIX A: SURVEY QUESTIONNAIRE

APPENDIX A

TELECOMMUNICATIONS ANNUAL REPORT

SURVEY QUESTIONNAIRE

1. What effect is deregulation of AT&T having on your business? _____

2. Have you addressed the problem of high-speed transmission of data (do you use T-1 or higher speeds)?

_____ Yes _____ No

If not, how do you plan to solve it? _____

3. What approximate percent of your total transmission activity is devoted to voice?

_____ % To data? _____ %

4. Have your networks been integrated for both? _____ Yes _____ No

5. What kind of lines are you currently using? _____

6. How do you plan to control communications costs? _____

7. What plans for change have you made over the next 6-12 months? _____

Over the next 12-24 months? _____

Over 24 months? _____

8. What issues would you consider important in a technology-oriented annual report? _____

9. What do you feel is the outlook (thrust and direction) for your industry over the next five to ten years. _____

10. How do you handle line/network problems? _____

11. Do you have network control centers? _____ Yes _____ No
How are they being used? _____

How are they tied together? _____

APPENDIX B: LIST OF ABBREVIATIONS

APPENDIX B: LIST OF ABBREVIATIONS

- ATT-IS American Telephone and Telegraph Information Systems Division.
- BOC Bell Operating Companies.
- DDS Dataphone Digital Service.
- EIA Electronics Industries Association.
- EMI Electromagnetic Induction.
- FCC Federal Communications Commission.
- LED Light-Emitting Diode.
- Mbps Millions of bits per second.
- MUX Multiplexor.
- PBX Private Branch Exchange.
- RBOC Regional Bell Operating Company.
- RFI Radio Frequency Interference.

